HELMHOLTZ – WITH ENERGY INTO THE FUTURE

ANNUAL REPORT 2010

HELMHOLTZ ASSOCIATION OF GERMAN RESEARCH CENTRES

Research in Germany
Land of Ideas

HELMHOLTZ
ASSOCIATION

CONTENT

The Helmholtz Annual Report 2010 illustrates the actual costs for research in 2009 and the financing of research programmes as recommended by the Senate for the years 2009-2013 for the research fields Earth and Environment, Health as well as Aeronautics, Space and Transport in addition to the financing recommendations for the programme period 2010-2014 for the research fields Energy, Key Technologies and Structure of Matter. The general report section presents the development of the Helmholtz Association from 2009 to September 2010.

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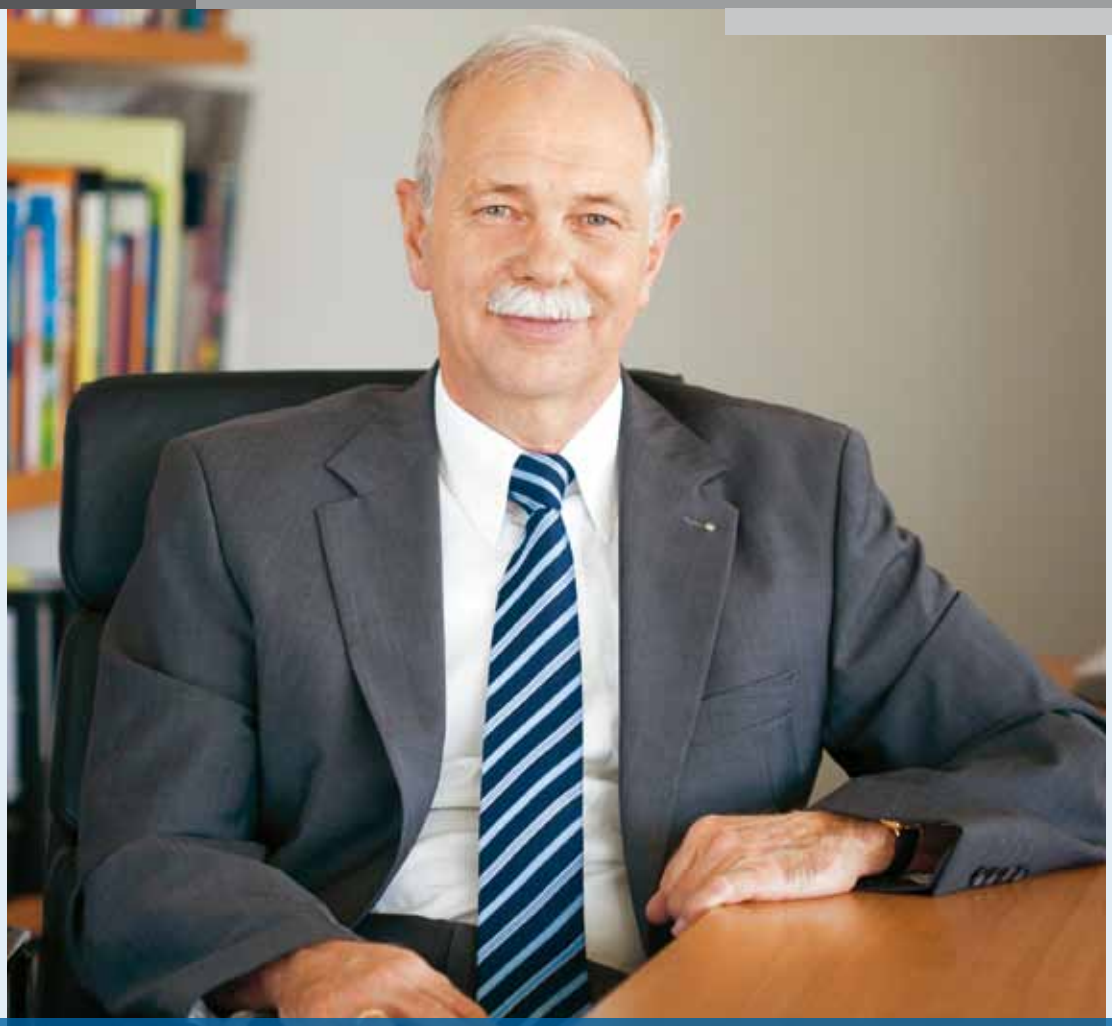
We contribute to solving grand challenges which face society, science and industry by performing top-rate research in strategic programmes in the fields of Energy, Earth and Environment, Health, Key Technologies, Structure of Matter, and Aeronautics, Space and Transport.

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.



PROF. DR. JÜRGEN MLYNEK, President of the Helmholtz Association

HELMHOLTZ – WITH ENERGY INTO THE FUTURE

Dear Readers,

"With Energy into the Future" is the motto informing this year's report regarding our activities in research and research politics. We adopt the topic of the current scientific year, for energy is indeed a key issue for our future. Our current energy mix based on combustion of fossil resources fuels the global climate change and the sinking of the oil production platform Deepwater Horizon in the Gulf of Mexico demonstrated to us the potential consequences of extracting oil deposits.
Providing the population with secure and sustainable energy will be decisive as regards the prosperity and quality of life of the next generation. At the same time, some technologies still are in their infancy. This is what we work on in the research field Energy, by increasing the degree of effectiveness of conventional power stations, advancing the use of solar energy and biomass and by researching the long-term vision of a fusion power station. Simultaneously, the research fields Key Technologies, Aeronautics, Space and Transport and Earth and Environment also contribute new impulses for the development of energy technologies.

The motto can be read also in the figurative sense: In order to safeguard the future we have to proceed with careful consideration and then act energetically, following the maxim of Hermann von Helmholtz, who demanded also of basic research the application of findings for the benefit of society.
In this annual report you will likewise read how we approach these issues, which strategies we employ, for instance, in systematically continuing to develop the technology transfer now or how we support young people in achieving their full potential by means of comprehensive talent management.

Yours Jürgen Mlynek

THE PRESIDENT'S REPORT

2010

THE YEAR OF ENERGY

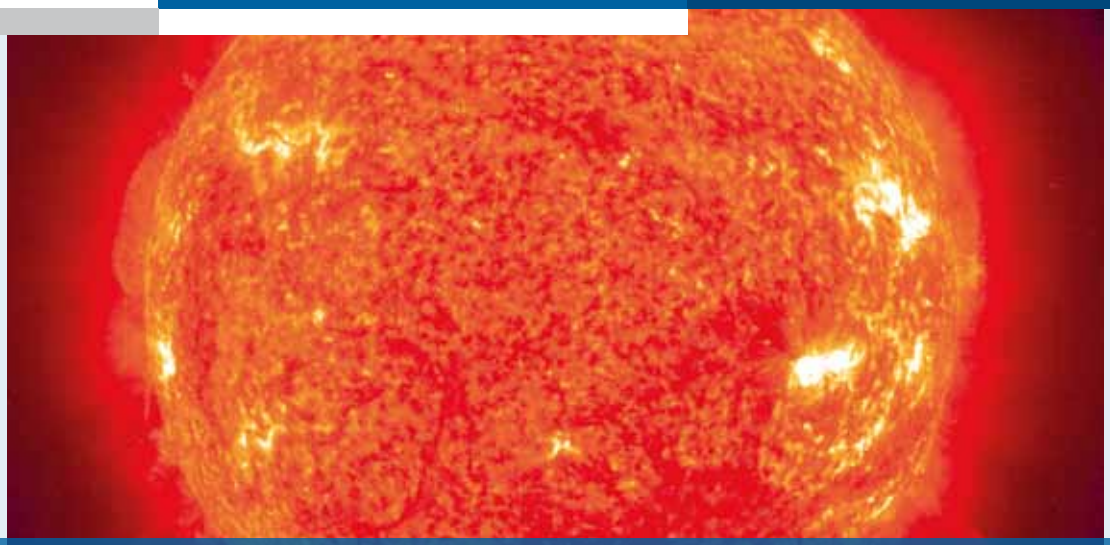
WITH ENERGY INTO THE FUTURE

Our goal is defined by the jointly devised mission: Through top-rate research we contribute towards solving the major and urgent questions society is facing and thus to securing the future. We achieve this by exactly identifying these questions in a broadly designed strategy process and by aligning our research accordingly.

One of the most important questions is how we can satisfy the energy demand of the continuously growing human race in future without further accelerating the climate change. For this reason, the German Federal Ministry of Education and Research declared 2010 the "Year of Energy" and conceived a campaign to address a large audience. In doing so, the Helmholtz Association gave its support in an advisory capacity from the very beginning on and is, in addition to the general initiative "Science in Dialogue", the partner of the science year of energy.

Seven Helmholtz Centres work in the research field Energy and between them perform approximately half of the energy research funded by public money. Here, we look into all relevant options of energy supply. For example, we research how the degree of effectiveness of conventional power stations can be increased and whether and how the greenhouse gas carbon dioxide can be precipitated and safely stored. Likewise, nuclear safety is an important research field, both in the operation of nuclear reactors and in nuclear waste disposal. The Helmholtz Association works also on utilising the process of nuclear fusion, from which the sun draws its energy, for producing energy here on earth. Naturally, we are also active in the field of renewable energies, we have achieved break-throughs in solar cell research, developed new components for solar thermal power stations and are researching the utilisation of geothermics and biomass (more on the Helmholtz Centres energy research on pages 16ff).

The further development of renewable energies still requires major technical innovations and break-throughs. In particular, we need new solutions for storing and transporting energy. Here, we systematically increased our research efforts, with the additional support from the economic stimulus package II opening up new possibilities: In particular, we are in the process of establishing together with partners from universities, research institutions and the economy two competence associations on battery research, which are coordinated by the Helmholtz Centres in Karlsruhe (Competence Association South) and in Jülich (Competence Association North).



THE SUN HURLS GIGANTIC CLOUDS OF HOT, CHARGED GASES INTO SPACE. ONE OF THE TASKS FOR BASIC RESEARCH IS TO INCREASE THE UTILISATION OF SOLAR ENERGY. Photo: ESA

In addition, we are starting an energy and hydrogen storage initiative. Energy consumption can be considerably lowered by storing energy and many expedient process optimisation measures are only made possible by using storage facilities. In 2009, the Federal Ministry of Economics asked the Helmholtz Association to devise recommendations for the further development of the Federal Government's energy research policy and to take the lead in the cooperative drafting of a concept for an integrated energy research programme for Germany, which was published jointly by the Academies of Science (Leopoldina, acatech and BBAW). We are convinced that we will remain dependent on using so-called bridging technologies such as nuclear energy for several decades more. In the long term, research assumes that the world-wide energy supply can be based on a mix of renewable energie sources - augmented by nuclear fusion, which hopefully is fully feasible by then.

Our expertise on the field of energy research is internationally recognised as are also our management competencies in the building of complex cooperations. Therefore, the European Institute of Innovation and Technology (EIT) chose the concept of the Karlsruhe Institute of Technology (KIT)-InnoEnergy for establishing an encompassing and strong "Knowledge and Innovation Community" (KIC). In the initial phase, the EIT provides the KIC InnoEnergy with an estimated sum of around 30 million Euros annually until 2014. The goal is to create a sustainable energy system for Europe by 2050. The concept for the structure of the KIC InnoEnergy is based on already existing cooperations the KIT maintains with partners in France, the Netherlands, Spain, Poland and Sweden. Well-known enterprises as well as universities and extramural research institutions are being involved. The Helmholtz Association also has a part in the two other KICs the EIT had put out to tender: Through the Climate-KIC, the Helmholtz Centre Potsdam - GFZ German Research Centre for Geosciences and the Potsdam Institute for Climate Impact Research, member of the Leibniz Association, will intensify the European cooperation for climate research and adaptation to global change. And the KIT is involved as a partner in the EIT-ICT-KIC on information and communication-technologies.

> In the long term, research assumes that the world-wide energy supply can be based on a mix of renewable energy sources – augmented by nuclear fusion, which hopefully is fully feasible by then.

Successfully into the Next Round with PoF and Joint Initiative

In the past year, we successfully completed the review of all research fields within the context of Programme-oriented Funding (PoF). Since January 2010, the research fields Energy, Key Technologies and Structure of Matter are also in the second funding period and thus enjoy planning reliability until 2014. Altogether 347 experts from international research institutions have been engaged in the reviewing process and supported us in our striving towards even more precise identification of the strategically important research fields and increased funding of particularly dynamic fields (more on this on p. 12 f). Programme-oriented Funding has proven a valuable instrument and now is being further developed in discussion with the Association's Centres as well as the funding bodies of the federal and state governments.

The lively exchange between the Centres is worthwhile, for as an association we carry more weight than a single Centre could in order to be a major player in the research region Germany and Europe. Together with our partners from the Alliance of Science Organisations we promoted the continuation of the Joint Initiative for Research and Innovation in the past year. With success: The Joint Initiative for Research and Innovation will be continued as of 2011 and the annual increase

HIGH-TEMPERATURE MATERIALS, WHICH COULD IMPROVE THE EFFICIENCY OF POWER STATIONS, ARE RESEARCHED AND TESTED IN RADIATION FURNACES. Photo: FZJ

of the budget of the extramural research institutions will grow over the next five years from currently three to ultimately five percent.

The Helmholtz Association's concept for utilising this increase comprises three fields: The strengthening of the research work within the programmes, the further development of the spectrum of our research topics via the portfolio and foresight process and the support of this further development through adaptation of the investment and impulse fund budget. This makes it possible to equip even better those research projects rated particularly worthy of promotion by the programme reviewers and at the same time take up new topics to a greater degree, as for example the subject of water research. This includes also the building of important research infrastructures such as, for instance, the Cohort for health research as well as overall research cross-section subjects such as system analysis.

By including strategically important university partners, that is, the networking within the German scientific system, another core goal of the Joint Initiative for Research and Innovation is achieved.

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Strategic Partnerships and Helmholtz Institutes

One of the goals agreed on within the Joint Initiative is the further development of strategic partnerships. Thus with the KIT Regulation becoming effective in October 2009, the merger of the Research Centre Karlsruhe with the Technical University Karlsruhe to form the Karlsruhe Institute for Technology (KIT) took place. With the addition of the Future Concept of the "Jülich-Aachen Research Alliance – JARA" between the Forschungszentrum Jülich and the RWTH Aachen, the Helmholtz Association thus created new structures together with its university partners and hence created the conditions to successfully further develop the research partnership within Germany also in the second round of the federal and state governments' Initiative for Excellence.

In 2009, three Helmholtz Institutes were founded in federal states where the Helmholtz Association was not as yet represented by a centre. The Helmholtz Institutes intensify and institutionalise the partnership between universities and Helmholtz Centres. As a kind of outpost of a Helmholtz Centre, they are set up on the university campus and the head scientists are appointed in cooperation with the partnering university. The Helmholtz Institutes are financed by the federal government (90 percent) and by the respective state government of location (10 percent) and can look forward to about 5.5 million Euro annual budget in the final stage of build-up. In the Saarland, the Helmholtz Centre for Infection Research in Braunschweig and the Saarland University established the Helmholtz Institute for Pharmaceutical Research Saarland on the Saarbrücken campus. In Thuringia, the Helmholtz Institute Jena merges the competencies of the Friedrich Schiller University in the field of high-power laser physics with the expertise in accelerator, laser and x-ray technologies of the Helmholtz Centres DESY and GSI. With the Helmholtz Institute Mainz in Rhineland-Palatinate, the GSI Helmholtz Centre for Heavy Ion Research in Darmstadt and the Johannes Gutenberg University Mainz strengthen their long-standing cooperation in the field of nuclear physics and nuclear chemistry in order to research questions regarding the structure, symmetry and stability of matter and anti-matter. The partners expect of this bundling of forces a significant boost in their joint research, in particular regarding the future experiments at the international FAIR Centre in Darmstadt.

In the research field Health, we create new structures to strengthen health research throughout Germany. An important milestone in the cooperation with universities was the establishment of a new Helmholtz Centre, the German Centre for Neurodegenerative Diseases (DZNE) in Bonn with six university locations, in April 2009. The German Centre for Diabetes Research, founded in June 2009 under significant contribution from the HMGU, likewise contributes towards creating national pools for the researching of relevant widespread diseases. Currently, four German Centres of Health Research are being formed through a competitive procedure around one respective Helmholtz Core Centre to set further impulses in health research. These centres focus on major common conditions such as cancer, cardiovascular, pneumonary and infectious diseases and augment the two already established German Centres for Diabetes Research and Neurodegenerative Diseases. By these long-term partnerships, basic research is effectively strengthened and the fast translation of research results into clinical practice is particularly promoted.

New Infrastructures

The building and operating of major research infrastructures is a unique feature of the Helmholtz Association. The further development of such large-scale facilities continue also into the future in order to guarantee optimal research conditions for the scientific community here and abroad.

The realisation of international large-scale projects such as European XFEL and FAIR, which are coordinated by the Helmholtz Association, has been considerably advanced during the year of report. For instance, the international agreement for building the 3.4 kilometre long European x-ray laser facility XFEL at DESY was signed at the end of 2009. XFEL will produce ultra-short x-ray laser flashes, the luminosity of which is billions of times higher than that of the best x-ray sources of an ordinary kind. Furthermore, the rebuilding activities on the electron storage ring PETRA at DESY were completed by the end of 2009. Now, the world-wide most brilliant x-ray source PETRA III is available on that site for the scientific community and offers excellent experimental possibilities. Also, the Heidelberg Ion Beam Therapy Centre HIT was opened in November 2009. This novel irradiation facility for tumor therapy with heavy ions was conceived by Helmholtz experts from GSI and DKFZ, built in cooperation with the Siemens company and is now being operated by the Heidelberg University Hospital.

In order to support the future building of new research infrastructures through the Helmholtz Association by joint strategic planning, a Helmholtz roadmap for research infrastructures is being devised since the beginning of this year. This roadmap is coordinated with the national roadmap and embedded into the European context. Thus, in juncture with the portfolio process and the investment procedure, a continuous process is established for the strategic planning for establishing research infrastructures within the Helmholtz Association.

> The building and operating of major research infrastructures is a unique feature of the Helmholtz Association.

The National Cohort Study, which is still in its set-up phase, is an entirely different kind of research infrastructure. It is a long-term study with 200,000 healthy test persons, initiated by the Helmholtz Association, which is realised in cooperation with university partners. Its goal is the identification of health risks as well as of the influence of behaviour and environmental factors on health.

Activities Reconstruction East

As a result of the federal government's targeted promotional policy in cooperation with the state governments, numerous

research institutions could be upgraded and further developed 20 years after the reunification. Since the reunification, the Helmholtz Association systematically promoted select scientific institutions in the new federal states and incorporated them into the Association due to their scientific quality and strategic orientation. In taking these decisions, the Association followed the recommendations by the science council. It is also due to this enduring activity on part of the Helmholtz Association, that such an important research community could be maintained and accordingly developed on a high level of scientific quality in the five new federal states.

For purpose of strategic development of the field Earth and Environment, the UFZ Centre for Environmental Research Leipzig-Halle (today Helmholtz Centre for Environmental Research - UFZ) with its sites in Leipzig, Halle and Magdeburg and the Geoscience Research Centre Potsdam (today Helmholtz Centre Potsdam - German Research Centre for Geosciences GFZ) were welcomed to the Association.

The important research field Health could be strategically developed by incorporating the Max Delbrück Center in Berlin Buch into the Helmholtz Association. Furthermore, several eastern German research institutions were taken over and enlarged across research departments as outposts of large Helmholtz Centres: Amongst these are the AWI sites on the Telegrafenberg in Potsdam, the IPP Part-Institute in Greifswald, the DESY sites in Zeuthen and the HZG sites in Teltow as well as the DLR sites in Berlin-Adlershof and Neustrelitz. Since last year, these are augmented by sites of the newly founded DZNE in Magdeburg, Rostock-Greifswald and Dresden as well as the new Helmholtz Institute in Jena.

Since the German reunification, the Helmholtz Association promoted scientific institutions in the new federal states.

With the incorporation of the Research Centre Dresden-Rossendorf (FZD), hitherto a member of the Leibniz Association, another major research institution in the five new federal states will be part of the Helmholtz Centres as of 2011. This new centre will adopt the name Helmholtz Centre Dresden-Rossendorf. By entering into the Helmholtz Association, the Research Centre's funding will be taken over by the federal government to 90 percent, so that the FZD's potential can be further developed.

With the programme "Top-Level Research and Innovation in the New Länder", the Federal Ministry of Education and Research recently created a new instrument of funding, with the Helmholtz Centres being successful also in the second round of calls. Headed by the Helmholtz Centre Berlin, a Competence Centre for Thin-Layer and Nano Technology for photovoltaics is being built.

Furthermore, the Helmholtz Centre Potsdam and the AWI are included in the integrative project "PROGRESS", which serves to research natural threats, climate change and sustainability. In addition, the GFZ enjoyed success with the integrative projects "GeoEn" and GeoX", in which technologies enabling a climate-friendly and sustainable exploitation of resources were developed.

The Next Steps: Living the Mission, Strengthening the Technology Transfer, Promoting Talent

Living the Helmholtz Mission means maintaining a continuous dialogue with society, politics and the economy and in doing so to identify the so-called *grand challenges*. We have to assess whether we are working on the right topics and whether in so doing we can be efficient and successful with sufficient critical mass. Our research is a dynamic Process. Therefore,

INNOVATIVE SOLAR CELLS CARRY THE PROMISE OF HIGHER DEGREES OF EFFICIENCY AT LOWER MATERIALS USAGE. Photo: HZB

we are open towards regular readjustments in our goal-setting. For the purpose of structuring this path, all Helmholtz Centres work together in the portfolio and foresight process and on the roadmap for the future research infrastructure. Within the context of this portfolio and foresight process, the Helmholtz Association has established dialogue platforms with the funding partners in order to coordinate long-term strategies. Current examples are the subjects climate research, supercomputing and the development of the National Cohort Study.

In future, we will increase the technology transfer: Research results are to be translated faster than has been the case into such products, procedures or services from which society, the people and the economy profit. Therefore, we created a validation fund in addition to the established measures such as Helmholtz Enterprise with the purpose of enabling scientists from Helmholtz Centres to further develop their research results towards marketable products and services (more on technology transfer p. 88f).

The basis of our success is the promotion of talent. Here, too, we developed new structures using funds from the Joint Initiative for Research and Innovation. In the past year, further Helmholtz Graduate Schools and Helmholtz Research Schools could be established in order to optimally support PhD students at Helmholtz Centres during their doctorate. With the Helmholtz Management Academy we have developed an attractive continuing education programme for middle management levels. This is now augmented by offers for the Helmholtz Young Investigators Groups as well as by a programme for the programme spokespersons and the institute and department heads. The Mentoring Programme “Taking the Lead” enables highly qualified women towards an exchange with experienced mentors from economy, science and politics and supports them in planning their professional career (more on the diverse measures of talent management on p. 90f). By way of successful instruments such as the Helmholtz School Labs and the “Tiny Tots’ Science Corner” as well as new services such as the travelling exhibition “Wunderkammer Wissenschaft, or “the cabinet of scientific curiosities” and the Centre for New Technologies at the Deutsches Museum in Munich we introduce children and young people to research in a targeted manner and show them that science and engineering are attractive professional fields. An encompassing talent management with services at all levels is part of the Helmholtz core culture, with the purpose of winning over the best heads worldwide. For our future is shaped by people. Fully committed, they work on solutions for the great challenges, be it health in a rapidly aging society, the climate change or the supply of water or energy. In another sense, we adopt this notion in our annual motto: With Energy into the Future!

> An encompassing talent management with attractive offers on all levels is part of the Helmholtz core culture.

At the end of the reporting period, the unexpected death of one of our board members overshadowed the successful accounting year: Prof. Dr. Jürgen Wehland, Scientific Director of the Helmholtz Centre for Infection Research in Braunschweig, passed away on 16 August 2010. He decisively contributed to shaping and characterising health research within the Helmholtz Association. We will be continuing his work according to his principles with joint forces.

PROGRAMME-ORIENTED FUNDING WITHIN THE HELMHOLTZ ASSOCIATION

A PERFORMANCE RECORD

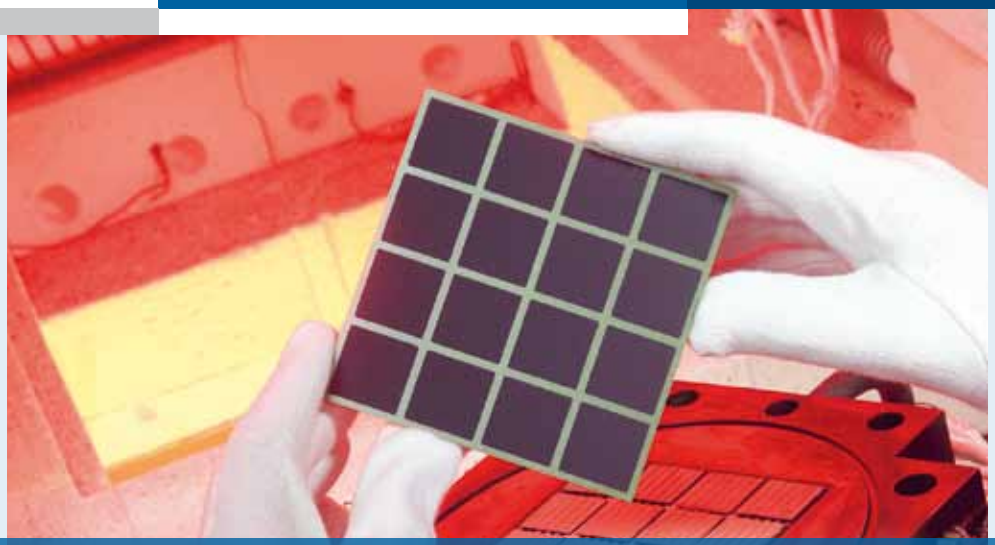
The Helmholtz Association looks back to nearly ten years of Programme-oriented Funding. This procedure has emerged to become the most important instrument for strategically aligned research and for the transparent allocation of research funds in cooperation and competition.

With this instrument, the Association clearly emphasises main issues while maintaining its profile across all Centres as regards content, strategic relevance, competitive distribution of the provided means as well as maintaining internal and external networking. As a result, the Helmholtz Association is in the position to meet the central challenges of science, politics and society in an even better manner and to perform internationally competitive top-rate research.

Since its introduction in 2001 – within the context of reforming the Association – Programme-oriented Funding has been through the review process twice. It became apparent that the reform achieved its goals and promoted or even only made possible a multitude of positive developments as well as stimulation of research topics. Programme-oriented Funding decisively contributed to the Centres aligning themselves according to strategic programmes within the competition, networking amongst each other and sharpening their profile as regards content. This stimulation is supported by the flexible programme setup. It enables the bundling of competences and resources towards an advantageous scope: from major programmes with numerous participating Centres to small programmes with only one participating Centre (see graph). Both the programme setup and its implementation require an intensive dialogue between Centres and a close cooperation across Centres. Thus, the resources of the Helmholtz Centres are bundled in a targeted manner, the critical mass for research topics is achieved and synergy effects realised. On the one hand, this leads towards the development of superordinate strategic initiatives and enables the Centres to regularly realign themselves – based on research policy requirements – and to always work on the important and future-oriented topics. On the other hand, new paths of cooperation open up, enabling joint planning for investments and thus the building and operation of complex, highly demanding research infrastructures. Thus the Helmholtz Association's mission and responsibility is filled with life in an excellent manner. This is the only way to investigate questions of high complexity, develop system solutions and to translate insights into applications.

The science adequate controlling process introduced within the context of Programme-oriented Funding safeguards the transparent and standardised portrayal of key data and developments from research. This enables reliable tracking of progress and, by the inclusion of external review panels, the continuous comparison with other institutions within the country and abroad. This singularly valuable gain in transparency as regards processes and application of resources both internally and externally is a basic requirement for enabling direct correlation between application of means and result. This is characteristic of the Helmholtz Association within the national and international scientific community yet also in its dialogue with politics and society.

The Association thus achieved to increase its impact in the national and international context. It attained a driving role as an architect in certain research fields as well as a partner in the implementation of entirely new forms of cooperation with universities and advances the building of complex infrastructures in a leading role. This significantly strengthened the national and international visibility of the Helmholtz Association's performing power and competence in system solutions. Today, the Association acts as an excellent, interesting and dependable

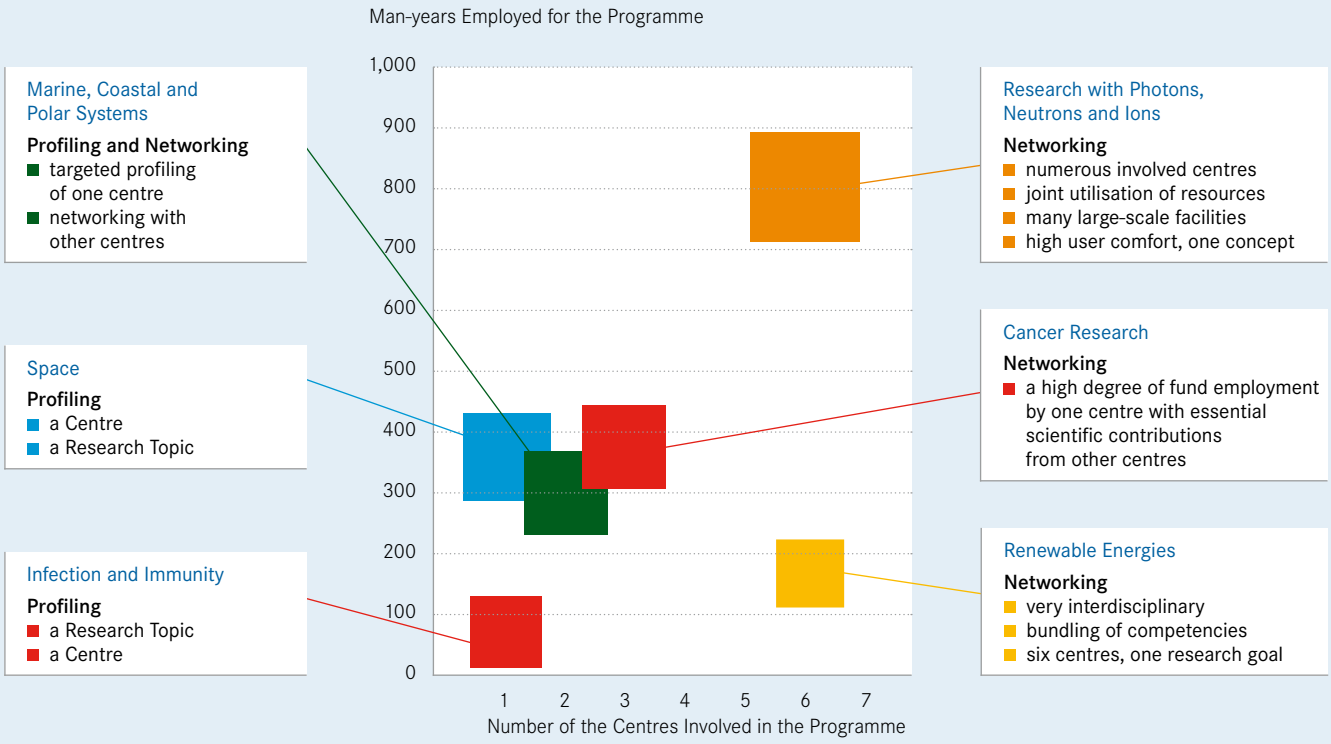


INCREASING EFFICIENCY BY RESEARCH: HIGH-TEMPERATURE FUEL CELLS UTILISE CHEMICAL ENERGY TO GENERATE ELECTRICITY. Photo: DLR

partner within the national and international scientific system in particular as regards international large-scale projects and emerges both modernised and strengthened from the process of Programme-oriented Funding.
Since the introduction of Programme-oriented Funding ten years ago, the national and international scientific community has distinctly changed. Given this background, the Helmholtz Association currently works on adapting this procedure to the complex, newly created structures and framework conditions while maintaining the Helmholtz mission. As the strategic programme with its leitmotifs “Competition” and “Cooperation” has proven to be an extremely valuable and efficient instrument, the Helmholtz Association strives to maintain this instrument as regards its basic principles.

PROFILING AND NETWORKING

The procedure of programme setup within the context of Programme-oriented Funding guarantees a high degree of Flexibility.



The procedure of Programme-oriented Funding provides a flexible framework in order to find the most effective form of networking and utilisation of resources for research topics depending on their focus and scope.

With Energy into the Future

CURRENT HELMHOLTZ RESEARCH PROJECTS

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

Energy - its supply, its use, and its costs - has clearly moved to the top of the research agenda world-wide, driven by increasing energy demands, increased constraints on available energy supplies, and a greatly increased awareness of the environmental impacts. At stake is not only whether we will have the energy supplies needed to maintain our living standards, but also who will dominate the world-wide energy markets. The answer to such questions matters enormously to Germany as a major exporting nation: A revolution in energy production and use is underway and those who dominate this new energy sector will gain the jobs - and gain the profits. The energy sector is highly sensitive to technological innovation - and we know that innovations in the market place ultimately rest on a foundation of basic and applied research. The research portfolio pursued by the Helmholtz Association plays a key role in building this foundation for Germany - from biological, material nuclear sciences to electronics and informatics.

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

"The connection between energy and mobility has become apparent the latest since the public discussion regarding CO_2. The Helmholtz Centres are working on various solutions. They develop new biofuels for conventionally powered vehicles and advance electro-mobility. In doing so, they also work on technologies to render the distribution, storage and tapping of energy efficient. Politics faces a double challenge here: For one, research in the field of energy generation and especially of battery technology needs to be increased. At the same time, we also have to publicly advertise towards keeping the electric kilowatt hour for the mobility offering in Germany affordable when compared internationally."

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

"Allergies are on the advance and people's health is increasingly strained by environmental factors such as particulate matter or rising ozone levels. These are some of the effects of human-environment interaction in an industrialised world. The resulting global challenge for energy and health research today is to counteract this with innovative concepts derived from basic research. Synthetic biology offers a future-oriented approach. It has the potential to revolutionise the generation of energy and biotechnology."

RESEARCH FIELD ENERGY

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

GOALS AND ROLES

In the research field Energy, Helmholtz scientists work on securing the energy supply in the long-term and in a sustainable manner and on developing solutions to this end, which are economically and ecologically acceptable. This requires the holistic examination of relevant chains of energy taking into account framework conditions and concomitant phenomena including climate and environmental consequences. In doing so, the examination of all primary forms of energy and the encompassing researching of innovative technologies for the efficient and effective conversion, storage and utilisation of energy forms is indispensable.

The long-term goal is the complete substitution of those energy sources subject to a limited time frame with energy sources that can be used in a sustainable, durable and climate neutral manner. Short- and medium term goals include lowering the energy consumption through efficient conversion and utilisation, reduction of dependency on imports within Germany and Europe, the research on new storage technologies, the reduction of climate and environmental impact and the safeguarding of special demands in mobile applications.

The Helmholtz Association derives its energy research strategy from this overall spectrum. It builds on the already available competences and experiences of the Helmholtz Centres. The expertise of other scientific and industrial partners are taken into consideration. At the same time, future fields are identified for which the Helmholtz Association needs to build up and develop new competences.

The energy demand of today's and future generations requires the development of new technologies, from which competitive innovations can grow. With this target in mind, scientists investigate, amongst other things, the potential of renewable energy sources such as solar energy, biomass or geothermal energy. They work with increased effort on raising the efficiency of conventional power stations and the economic use

of energy. The work on generating energy by way of nuclear fusion develops a new source of energy in the long-term. This path is a major scientific and technological challenge, which is being put forward in international cooperation. Ultimately, the Helmholtz Association contributes to the secure operation of nuclear reactors as well as to the safe treatment and disposal of highly radioactive waste by way of its globally unique know how in the field of nuclear safety research.
The diverse research activities are augmented by structural developments within the Helmholtz Association strengthening energy research. The fusion of the University Karlsruhe and the Research Centre Karlsruhe into the Karlsruhe Institute of Technology (KIT) – a successful contender within the excellence competition of the federal and state governments – led, amongst other things, to the establishment of a KIT Centre Energy, which is to become the leading European centre for energy research.
A first major success has been achieved already: In a hard European competition for the establishment of so-called Knowledge and Innovation Communities (KICs) in the field of sustainable energy research, the application KIC InnoEnergy, coordinated by the KIT and, by the way, the only application coordinated by a German consortium amongst the final six applicants, was chosen for funding by the Governing Board of the European Institute of Innovation and Technology (EIT).
In the section JARA-ENERGY of the Jülich-Aachen Research Alliance JARA, the Forschungszentrum Jülich and the RWTH Aachen merge their complementary competences in an internationally pioneering research partnership in order to develop new energy solutions. Finally, solar energy research is strengthened by a competence centre for thin-layer and nanotechnology for photovoltaics founded by the Helmholtz Centre Berlin für Materialien und Energie in cooperation with the industry and the TU Berlin.

THE PROGRAMME STRUCTURE
IN THE FUNDING PERIOD 2010-2014

Six Helmholtz Centres currently work together in the research field Energy of the Helmholtz Association: the Research Centre Karlsruhe, since 1 October 2009 Karlsruhe Intitute of Technology (KIT); the Forschungszentrum Jülich; the German Aerospace Centre (DLR); the Helmholtz-Zentrum Berlin für Materialien und Energie (HZB); the Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences and the Max Planck Institute for Plasma Physics (IPP) as an associate member of the Helmholtz Association. As of the year 2010, the Helmholtz Centre for Environmental Research – UFZ is also active in the energy sector. Up to 2010, the scientists worked in the four scientific programmes Renewable Energies, Efficient Energy Conversion, Nuclear Fusion and Nuclear Safety Research. With the beginning of the second funding period 2010-2014, the new programme Energy System Analysis is incorporated as part of the cross-research programme Technology, Innovation and Society, which is managed in cooperation with the research field Key Technologies (p. 54ff).

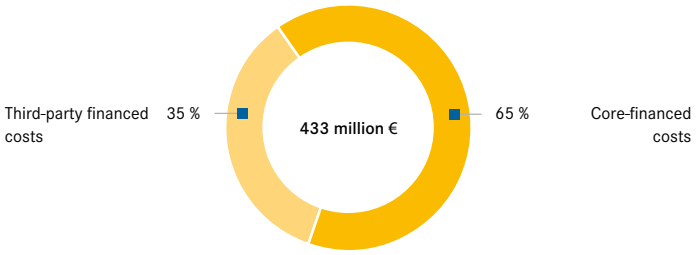
- Renewable Energies
- Efficient Energy Conversion and Use
- Nuclear Fusion
- Nuclear Safety Research
- Technology, Innovation and Society

The programmes are advanced by interdisciplinarian teams in international cooperation. Research infrastructures, large-scale experiments, pilot plants, test plants for large components, high-performance analysis systems and large computing capacities are at disposal for this purpose.

"Increasingly scarce resources, climate change and population growth constitute insistent questions regarding the future supply of energy. Unilateral answers bear a high risk. Research has a high measure of responsibility here. In this field, the Helmholtz Association makes a widely visible contribution in developing both renewable and long-term sustainable sources of energy."

PROF. DR. HERMANN REQUARDT, Senator of the Helmholtz Association, Member of the Managing Board of Siemens AG and CEO of the Healthcare Sector, CTO of Siemens AG and Head of Corporate Technology

Total costs of the research field Energy
Actual costs 2009: 433 million Euro
(incl. the share of non-programme-bound research)



THE PROGRAMMES
IN THE FUNDING PERIOD 2010-2014

For the second funding period, the Helmholtz Centres within the research field Energy readjusted and expanded their strategy to address the major challenges. In particular, energy research within the Helmholtz Association will in future not only focus on power generation, but will rather consider all application scenarios across the entire process chain and thus promote the systemic overall optimisation.
A cross-programme initiative for developing energy storage systems is planned that will be funded with a total of 12 million Euros between 2010 and 2014.

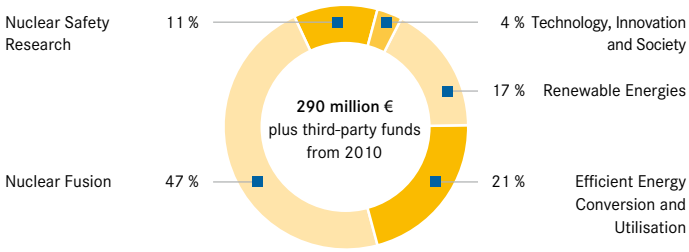
Renewable Energies Programme

The catalogue of topics is being expanded: Besides topics on generating power from solar and geothermal energy, research projects on biomass and solar fuel generation are being added. The research on photovoltaics continues to pursue the development of thin-layer solar cells to increase the degree of efficiency as close as possible to its theoretical limits with the lowest possible input of material and energy. Solar-thermal power plants located in the earth's sun belt could contribute substantially to the global generation of power as from around 2030. Commercial solar power plants have been built since several years, however with conservative technological approaches. The successful market launch of new technologies calls for further cost cuts. In the long-term, concentrating solar systems are to produce also solar fuels via thermal processes.
The geological subsurface in Germany offers great potential for generating heat and power. Geothermal research pools the competences of the participating centres to develop optimal technological solutions. The feasibility and economic efficiency of geothermal power generation is being studied in Groß Schönebeck.
The energetic use of biomass on basis of thermo-chemical processes and biogas production will become more sustainable in the second generation. The Bioliq procedure developed at the KIT and for which a representativ pilot plant was erected opens up new possibilities for this.

Efficient Energy Conversion and Use Programme

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 co-generation of heat and power as well as 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 requires innovative boosts for components such as turbo machines and materials that are capable of resisting higher temperatures.
The 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 achieved at the expense of a higher use of resources. In the medium term, solutions need to be developed which enable existing power stations to be retrofitted. The research goals in the field of fuel cells are to increase their lifetime and performance, to reduce the costs and to develop new processes and methods for analysing aging mechanisms and for quality assurance processes.
Research and development on superconducting components for power grids can contribute towards 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.

Structure of the research field Energy
Senate recommendation for core-financing 2010: 290 million Euro
(incl. the share of non-programme-bound research)



On the graphs:

The left graph shows the funds actually employed for the research field Energy during the report year 2009, divided into core-financed and third-party financed costs.

The right graph depicts the core-financed costs approved by the Senate for the year 2010. In addition, the graph shows the distribution of funds to the programmes from the second round of Programme-oriented Funding. A comparison of current numbers with the depictions from the previous years is possible only to a limited degree, since on the one hand, the Helmholtz Centres have undergone repositioning as regards their research fields and programme structure. On the other hand, the onset of the second round of Programme-oriented Funding brings with it a change from differentiated budgeting between R&D and infrastructure costs to absorption costing.

Nuclear Fusion Programme

The Helmholtz Association's Nuclear Fusion Programme is currently pursuing two priority goals: for one, to perform the German contributions towards building and operating the international Tokamak experiment ITER in Cadarache and, for the other, to finalise and operate the stellarator Wendelstein 7-X in Greifswald. ITER aims to prove the physical and in part also the 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 onwards).

Nuclear Safety Research Programme

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 here 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 Programme

The goal of this interdisciplinary programme across research fields is the investigation of ecological, economic, political, ethical and social aspects associated with new technologies in order to support decisions in politics, industry and society. The programme topics in the field of "Energy" aim at 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 reviews the whole energy chain process, 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

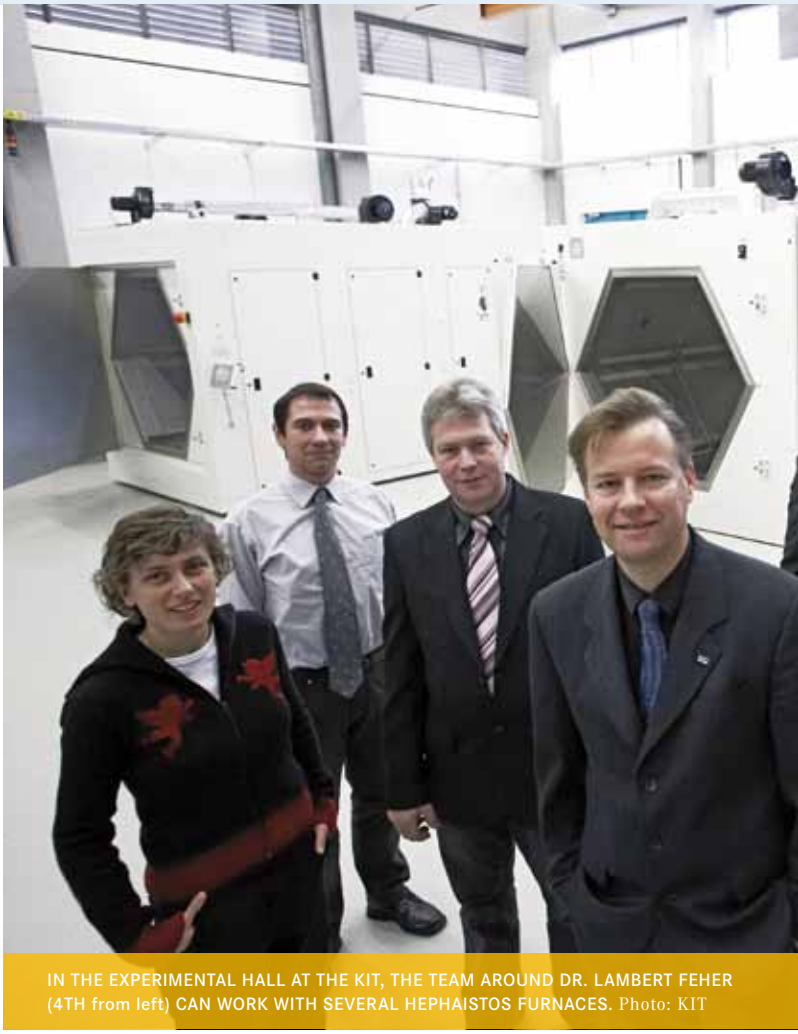
Karlsruhe Institute of Technology

STRONG PARTS FROM THE COLD FURNACE

Many parts of aeroplanes and automobiles are long since not made out of steel but from modern composite materials. They consist of carbon or fibreglass laminates bonded with special resins to form an extremely resilient material withstanding crash tests, elastically absorbing virbrations and which at the same time are as light as a feather. And this saves fuel. Yet so far such light-weight composites have to be produced in enormous furnaces, so-called autoclaves, under high pressures and temperatures, which uses up a lot of energy. But this could change: The microwave furnace HEPHAISTOS, developed at the Karlsruhe Institute of Technology in close cooperation with industry partners, will be able to produce light-weight composites of any shape and size for the industry and requires only about a fifth of the energy compared to the conventional production in the autoclave, as comparative measurement by EADS has shown.

"The microwaves simply heat up only those parts, which really have to be heated, such as the light-weight materials and not the furnace itself. You even can still touch the furnace, that's how cool it stays", explains Project Manager Dr. Lambert Feher from the KIT's Institute for Pulsed Power and Microwave Technology. "This saves 80 percent of energy and furthermore even improves the material properties."

At the core of this technology are microwave components as they are also used in households. They are located on the sides of hexagonal cylindrical modules measuring some two metres in diameter and one metre in length. The largest furnace of the experimental hall features three modules in a row, so that parts of a length of up to three metres can be produced in one cycle. Inside the furnace an almost homogenous microwave field is created, which can be optimised as to the shape of the part according to requirements by controlling the individual microwave radiators. "The microwaves transfer their energy target-oriented to the carbon fibres within the composite material and triggers these like antennas. This causes their surface to warm up and they conjoin fast and in a much better way with the surrounding matrix of resins", Feher explains. Whereas in a conventional thermal furnace the energy is transferred exclusively via thermal conduction, which is very low in carbon fibres. Therefore, the light-weight composites from the HEPHAISTOS furnace also are of an extremely good quality. Hardness and shear strength are greater, the various layers are more closely connected with each other and absorb an impact better, at the same time they are more elastic. "Apparently, microwave technology leads towards strengthening the network between fibre mesh and resin matrix", assumes Feher. However, what happens exactly within the material has not been understood in detail as yet. "Roughly speaking, we imagine that the microwaves lower the activating energies for certain chemical reactions and thus they are accelerated."



IN THE EXPERIMENTAL HALL AT THE KIT, THE TEAM AROUND DR. LAMBERT FEHER (4TH from left) CAN WORK WITH SEVERAL HEPHAISTOS FURNACES. Photo: KIT

LAMBERT FEHER:
"In a targeted manner, the microwaves heat only those parts, which are to be warmed up."

During the hardening process, Feher and his team observed with a thermal camera, how the heat spreads within the usually complex shape of parts. An homogeneous warming is optimal, which can be achieved in the Hephaistos technology via a programmed control of fields – another advantage compared to conventional thermal furnaces.

Additional funding from a Federal Ministry of Education and Research project running from 2006 to 2011 enables the KIT team to put the finishing efforts on the Hephaistos technology and above all brought sufficiently strong industry partners to the project: Amongst these are the aerospace companies EADS and GKN Aero-space, the chemicals companies BASF and Hexion, the automotive manufacturer Porsche as well as the producers of composites SGL Brakes and Fritzmeier Composites. Further large Hephaistos furnaces, which can produce also very large parts for aeronautics, are in their design stage

at the KIT's experimental centre. "We have developed the technology so far to be licensed to the industry", Feher states. And it works, too: For example, the firm GKN Aerospace installed a large-scale plant as first industrial customer already at the beginning of 2010 in Munich.
Yet in research a lot remains to be done as well: On the agenda are not just the question what exactly microwave radiation effects in the composite material but also the optimisation of the entire process. For instance, the calculations for controlling the microwave radiators still are very demanding: "Our next goal is to further refine control of the microwave fields so that we can process also very thick and asymmetrical parts", Feher says.

ANTONIA RÖTGER

Helmholtz Centre Potsdam
GFZ German Research Centre for Geosciences

HIDDEN RESERVES

A new term is spreading amongst Europe's energy experts: "Shale gas" could be translated "Schiefergas" in German. This denotes a natural gas located in dense, ancient clay formations yet which cannot be extracted with the usual methods. These long since known gas deposits can be economically exploited only since a few years ago. Their exploitation makes sense also because the transition to sustainable sources of energy will require many years more, during which fossil fuels will continue to be used. In such a case, natural gas is the first choice as it yields the same net energy as coal yet with 40 to 50 percent less of the climate gas carbondioxide.

MORE CLIMATE FRIENDLY THAN COAL

Shale gas emits 40 to 50 percent less carbon dioxide than coal for the same amount of usable energy.

In the US today, nearly every tenth cubic metre of natural gas comes from such rock formations. Here, Europe still is far behind. Only in 2009, two research projects started: Professor Dr. Brian Horsfield of the GFZ heads „Gas Shales in Europe" (GASH) and GFZ scientist Dr. Hans-Martin Schulz coordinates the core topic „Shale Gas" within the context of the compound project GeoEnergy. "In these projects, we investigate how shale gas is formed and what typical deposits in Europe look like" explains Hans-Martin Schulz. Presumably, there is a whole series of such deposits in England, Poland and Sweden, the Vienna Basin as well as in Lower Saxony and in the south of Germany. The reserves then are accessed by a vertical bore hole. Once the boring cutter reaches the natural gas layer, it turns horizontal and possibly bores horizontally for some kilometres more. Then water is pressed into the layer, opening up fissures in the rock, which are permanently stabilised by small quartz spheres within the solution. The natural gas then can escape from these fissures.

ROLAND KNAUER

JURASSIC ARGILLACEOUS ROCK ON THE COAST OF ENGLAND IS SIMILAR IN BUILD AS THE UNDERGROUND SHALE GAS SYSTEMS. Photo: TU Clausthal

THE DLR EXPERTS HERE CAN TEST NEW CONCEPTS IN A VARIABLE STORAGE TEST UNIT WITH EXCHANGEABLE INNER CONTAINER. Photo: DLR

German Aerospace Centre (DLR)

SALT, CONCRETE AND COMPRESSED AIR: STORAGE SYSTEMS DELIVER ENERGY ON DEMAND

Solar and wind power stations rarely conform to demand from electricity customers. Therefore, low priced and efficient energy storage systems are the key towards a reliable supply of electricity produced from regenerative sources. Researchers from the German Aerospace Centre (DLR) develop thermal and compressed air energy storage for the future supply with energy.

"We envision three application fields for our storage technologies", says Dr. Rainer Tamme, Department Head at the DLR Institute of Technical Thermodynamics in Stuttgart. With the help of thermal energy storage, conventional gas power stations could be operated more flexibly and hence more efficiently. Air pressed into subterranean cavities under high pressure can be used to smooth production peaks from wind parks. And ultimately thermal energy storage safeguards the electricity production of solar power stations for many hours at night.

Such thermal energy storage already today solves the storage problem at the first solar-thermal power stations. For instance, at the plants Andasol 1 and 2 near the city of Granada in the south of Spain more than 28,000 tons of liquid salts – a mixture of potassium nitrate and sodium nitrate – are heated to some 400 degrees Celsius during the day. The salts store the sun's warmth efficiently enough in order to power the steam turbines for up to seven hours after sunset. "However, such liquid salts have the disadvantage of causing high costs and turning solid at 220 degrees and hence become useless", says Tamme.

On the Stuttgart site and at the Plataforma Solar de Almería in Spain, the DLR scientists are already working on a cheaper alternative: Concrete, which can be heated to up to 400 degrees. "The firm blocks can on occasion also cool down without taking damage", says storage expert Dörte Laing. In principle, this technology is available already and waits to be adopted by the industry.

RAINER TAMME:
"Storage technologies render gas power stations more efficient, smoothen production peaks of wind parks and secure the electricity of solar power stations over night."

By contrast, so-called latent heat storage (LHS) units based on phase change materials still have to pass their field test. Again, these consist of many tons of salt, or to be precise, sodium nitrate. Yet in contrast to the liquid salts, these amounts are permitted to change phase, that is, solidify. The thermal conductivity indeed is so much reduced that it is difficult to liquefy the salt again. But numerous aluminium ribs across the salt reservoir can counterbalance this disadvantage. How well this principle for thermal energy storage actually works has to be proven this year at a reservoir with 14 tons of nitrate salt at a power station run by the Spanish electricity supplier Endesa in Carboneras. "This is currently the largest latent heat storage unit of the world and we expect results by the end of the year", says Laing.

These thermal reservoirs play only a minor role for wind power stations. For these provide already useable electricity. In order not to lose surplus kilowatt hours during phases of strong wind, they are to power air compression pumps. These press compressed air into subterranean cavities such as, for instance, salt caverns. Once the demand for electricity rises, the air can escape again and set the generators' turbines in motion. In cooperation with RWE, General Electric (GE) and Ed. Züblin AG, the DLR will build a compressed air energy storage unit with an electric power output of up to 200 megawatt by 2013. The "adiabatic compressed air energy storage for electricity supply", short Adele, is to provide intermediary storage for five hours for the power production of up to 40 wind turbines.
However, the compressing and release of compressed air is not a trivial matter. During compression, the air heats up to above 600 degrees. Conversely, it cools down when escaping. A high degree of efficiency of the compressed air energy storage of around 70 percent can only be achieved when the compression heat is also stored and later can be used to warm up the escaping air. And it is precisely there, where "Adele" will profit from the DLR's great expertise in the field of thermal energy storage.

JAN-OLIVER LÖFKEN

Forschungszentrum Jülich

SIEVES FOR CARBON DIOXIDE

Fossil power plants probably will remain a basic pillar of the world-wide provision with energy for a long time. Therefore, an important element in the battle against climate change could be the separation and storage of carbon dioxide from the exhaust fumes of coal or gas power stations. In order for this to be achieved with the minimum of energy possible, researchers within the Helmholtz Alliance MEM-BRAIN under leadership of the Forschungszentrum Jülich develop membranes made from polymer and ceramic materials. In doing so, they already early on cast an eye on the economic aspects and designed solutions feasible under power plant conditions.

STEFAN BAUMANN:
"By now, the demonstrator already has run for over 1,000 hours. That way, we can test whether the materials remain stable in the long-term also under the hard conditions at the power station."

One approach is the so-called oxyfuel process with the combustion of coal taking place in pure oxygen. Thereby, the exhaust fumes acquire a very high proportion of CO_2, which is much easier to deposit. Yet for this, they first have to separate air into nitrogen and oxygen to obtain oxygen from air. For this purpose, the Jülich researchers developed ceramic membranes and together with colleagues from the Fraunhofer IKTS built a first demonstration plant. The ceramic specialists succeeded in producing thumb-thick tubes with thin walls from the powdery raw material. If one now pumps the air from the tubes, only oxygen flows back through the ceramic walls into the tubes. This construction is surrounded by a furnace producing temperatures similar to those during the real power plant process.
"By now, the demonstrator already has run for over a thousand hours", Dr. Stefan Baumann from the Forschungszentrum Jülich sums up. "That way, we can test whether the materials remain stable in the long-term also under the hard conditions at the power station." In the meantime, the materials researchers have further optimised the ceramics. By adding chemicals, for example, they succeeded in increasing the temperature range in which the membrane remains stable and lets oxygen pass optimally .

UTA DEFFKE

THE CERAMIC MEMBRANE TUBES OF THE DEMONSTRATION PLANT LET THROUGH ONLY PURE OXYGEN.
Photo: Fraunhofer IKTS

Max-Planck-Institute for Plasma Physics

WENDELSTEIN 7-X PROGRESSES

One of the most important industry commissions in building the fusion plant Wendelstein 7-X was completed in May 2010: the production of the fifty superconducting solenoid magnets. The commission for this technologic core part of the experiment currently being developed at the Part-Institute Greifswald of the Max Planck Institute for Plasma Physics (IPP) was the hitherto largest single procurement in the Institute's history. "All other major components are also completed", says Professor Dr. Robert Wolf: "The production phase hence is finalised, the assembly of the large-scale experiment is in full swing."

ROBERT WOLF:
"If everything continues to go according to plan, Wendelstein 7-X will be completed in some four years and brought on line."

In addition to the fifty larger than man-sized, superconducting solenoid magnets and twenty additional coils producing the magnetic cage for the plasma, all other components are completed at the IPP: the massive supporting structure holding the coils in position, the twenty parts of the plasma vessel and its over 250 connecting pieces as well as ultimately the ten individual parts of the outer vessel – steel half-shells of 14 tons each. Once assembled, they will form a circular tube of 16 metres in diameter. In its 4.4 metre wide interior, this heat-insulating cool box later encases the entire coil ring cooled down to low temperature, in the interior of which in turn lies the plasma vessel with the many million degrees hot plasma.

Wendelstein 7-X, after completion the world-wide most modern fusion plant of the stellarator type, is intended to investigate this model's suitability as a power station, in particular its capability for permanent operation. The goal is a power station obtaining energy from the fusion of atomic nuclei - similar to the sun. For this, one needs to succeed in encasing the fuel, a hydrogen plasma, within magnetic fields and heat it to temperatures of above a hundred million degrees.

"In the assembly process, the single parts of the stellarator plant first are pre-assembled to make five almost identical modules", Robert Wolf explains: "These are then put together in a circle inside the experimental hall." In the meantime, work

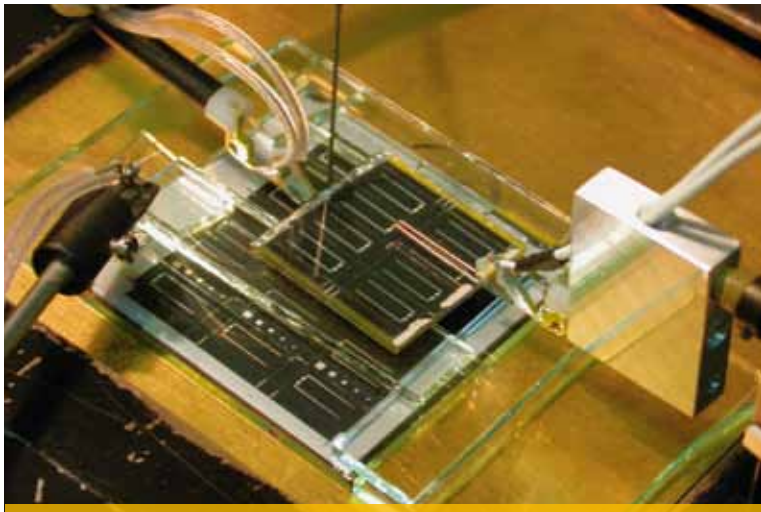
ONE OF THE FIVE PARTS OF THE OUTER VESSEL OF WENDELSTEIN 7-X. Photo: IPP/W. Filser

progresses at all five modules at the same time; two are already completed and stand in their final location on the machine foundations.
"Everything began in parallel at two pre-assembly stands", explains Robert Wolf, "where a special gripper carefully fed one of the six ton heavy solenoid coils over merely millimetre-broad spaces onto one part each of the plasma vessel. Then a second plasma vessel sector could be welded on one at a time and the thermal insulation at the seam could be closed. This super-insulation separates the low-temperature solenoid magnets from their warm environment. After this, six more coils were fed one at a time onto the vessel part, aligned and screwed together with one segment each of the supporting ring. After many control measurements, the first two semi-modules were then ready and both lifted to a third assembly stand."
While the next two semi-modules were assembled at the now vacated assembly stands, the first two module halves were joined together at the third assembly stand. Now the conductors for the electric interconnection of the coils was attached – "a rather difficult operation", according to Robert Wolf.
The stiff, metre-long superconductors, which are prepared for fitting at the Forschungszentrum Jülich, are already bent into their right shape. In parallel to this – by now in cramped conditions – the pipe-work for the helium cooling system of the coils was carried out. "Everything had to be tested as regards leak-tightness. Then sensors and measuring cables had to be laid, before the first and then the second module could leave the assembly stand in direction hall", Wolf remembers.
While these assembly steps are now repeated for the remaining modules, the already completed modules are encased in their outer shell at the hall and outfitted with 50 connecting pieces each, which connect the plasma and exterior vessels through the cold coil section. Once all modules are connected to form a ring on the machine foundations, the interior fitting inside the plasma vessel follows. In parallel to this, the systems for heating up the plasma are being built, amongst these the microwave heating, supervised by the Karlsruhe Centre of Technology, the supply installations for electric energy and cooling, the machine control as well as the numerous measuring instruments, which are to diagnose the behaviour of the plasma. Robert Wolf: "If everything continues to go according to plan, Wendelstein 7-X will be completed in some four years and brought on line." ISABELLA MILCH

Helmholtz-Zentrum Berlin für Materialien und Energie

MORE LIGHT FOR TANDEM CELLS

A solar cell always uses only a portion of the solar spectrum, that is it converts into power only a certain range of colours (frequencies). Therefore, what is more logical than to stack several kinds of solar cells on top of each other, in order to transform a larger portion of light into power? This approach

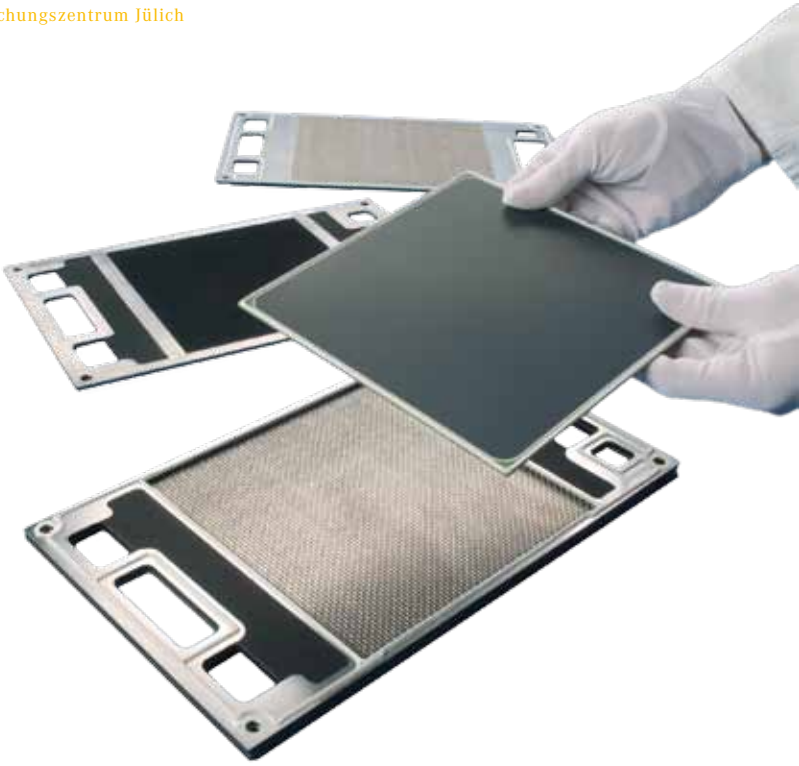


THE TOW INDIVIDUAL CELLS CURRENTLY ARE STILL STACKED MECHANICALLY IN THE LAB TO FORM A TANDEM CELL. Photo: HZB/M. Schmid

is being pursued to assemble tandem solar cells consisting of a top and a bottom cell. In doing so, certain colours of the light are absorbed by the top cell and converted into electric power, while the bottom cell uses the remaining parts of the colour spectrum.

MARTINA SCHMID:
"If one now would optimise the electric properties of the top cell, then efficiencies of above 20 percent were feasible for the tandem."

Yet in practice it appears that the top cell allows too little light to pass through to the bottom cell even at those frequencies, which cannot even be used for power production in the top cell itself. Now, Dr. Martina Schmid from the team of Professor Dr. Martha-Christina Lux-Steiner at the HZB achieved a significant improvement: In her PhD thesis on the optimal construction of chalcopyrite tandem solar cells, she developed an optical model of this layered cell and calculated which losses occur and where. This model enabled optimisation of the stacking structure and layer thicknesses of the tandem cell, so that the transparency of the top cell increased from 60 to 80 percent. As a result, the efficiency of the entire tandem cell could increase to above 10 percent. Before the optimisation only 8.5 percent was achieved. "If one now would optimise the electric properties of the top cell, for example by improving the material characteristics, then efficiencies of above 20 percent were feasible for the tandem", says Schmid. The physicist is now working on strengthening the absorption of certain frequency ranges and their conversion into electric power by aid of specially applied nano-structures. ANTONIA RÖTGER



THE SOFC CELLS DEVELOPED AT JÜLICH CAN BE LAYERED TO A „STACK“ AND DELIVER 250 W PERFORMANCE AT 700°C.
Photo: Forschungszentrum Jülich

Forschungszentrum Jülich

FUEL CELL ON CONTINUOUS DUTY

It runs and runs and runs. With 25,000 hours, the Jülich high-temperature fuel cell has achieved a new endurance run world record in June 2010. Good preconditions in order to provide not only cars or laptops with power in the future, but also homes and industrial processes. For fuel cells are hot candidates for a future and also more decentralised power supply. They feature high degrees of electric efficiency of up to 60 percent and do not emit harmful fumes. “Fuel cells are already equipped for the average 5,000 hours life-span of a car motor, yet in the household or for industrial applications life-spans of above 40,000 hours often are desired and this they do not achieve as yet”, says Dr. Robert Steinberger-Wilckens, head of the fuel cell project at the Forschungszentrum Jülich.

Fuel cells obtain electric power from charge separation of hydrogen and oxygen on specially coated electrodes and the ensuing reaction of the positively charged hydrogen with the negatively charged oxygen to form water. Similar to a battery, these electro-chemical energy converters also lose performance over time, amongst other reasons, because the reactivity of surfaces decreases. At the Forschungszentrum Jülich, fuel cells operating at high temperatures are being researched. In doing so, the electrolyte is not liquid but consists of a ceramic membrane layer between the electrodes. It allows the negatively charged oxygen particles to pass from one electrode to another only at temperatures from 600 to 1,000 degrees Celsius. The high-temperature cells have higher degrees of efficiency and the high temperatures can be used for further processes by way of cogeneration systems. Furthermore, they can be operated with various fuels – in addition to hydrogen also with natural gas or biogas. “However, the high temperature brings with it also some challenges, for the materials age faster”, says Steinberger-Wilckens. For example, the ceramic membrane loses its conductivity for oxygen because the crystalline structure slowly changes. And the so-called metallic interconnectors connecting several cells to form a more powerful stack oxidise more easily and can evaporate material, which deposits in the reactive layers and clogs these.

FUEL CELLS

High-temperature fuel cells are more efficient but age faster. The Jülich researchers have decisively improved the materials and hence the life span.

In order to prevent this, the Jülich researchers have decisively improved the materials and thus created the preconditions for their endurance run record. Thanks to newly developed ceramics, the operations temperature could be lowered. This in turn allows the use of cheaper steel for the interconnectors. In close cooperation with industry partners, two special steels were developed, which in combination with optimised protective layers render the cell much more robust. Also, they have the same expansion behaviour as ceramics, so that only minor mechanical tensions occur during heating. “The performance gain is distinct and a major step towards application”, Steinberger-Wilckens sums up.

If the fuel cell really is to play a major part in the provision of energy at some stage, it requires not just smooth operation. It is also important to secure the supply of fuel. For this, hydrogen, yet also methane from natural gas, gas from purification plants or landfill gas or diesel reformates can be considered. The main problem appears to be storing the hydrogen and the (energy) effort in producing the fuel.

Whereas cars could be powered entirely by hydrogen in the future, many heavy goods vehicles, ships or aeroplanes will continue to be powered by fossil fuels for the foreseeable future. Even so, fuel cells are an efficient alternative for alternators or generators to provide power on board for cooling units, air conditioners or avionics. For this purpose, they can be operated with the already available fuels. The key to this is a so-called reformer, which produces a hydrogenous gas as fuel for the fuel cells from diesel fuel or kerosene. Jülich researchers from the team around Dr. Ralf Peters developed an especially effective and long-lived reformer for this purpose. The trick: Diesel fuel is sprayed in very fine droplets into a specially shaped chamber and mixed with hot water vapour and air, before it is conveyed – as in automotive catalytic

converters – over a reactive surface, where it is separated into hydrogen, carbon monoxide and carbon dioxide. In order to optimise the hydrogen yield, the researchers calculated the complex flow characteristics at the Jülich super computer and thus developed the innovative reformer. For it is only in combination with such elements that fuel cells can unfold their versatile talents. UTA DEFFKE

Helmholtz Centre for Environmental Research – UFZ and Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences

MODELS FOR ENERGY FROM THE DEPTH

When the GFZ researchers get geothermal energy from several kilometres deep down to the surface in order to produce electric power and supply heat energy, they literally advance into unknown regions. Nobody knows exactly what it looks like deep down, which fissures and cracks there are and how the geothermal power station changes the underground. Yet such questions are of interest not only to researchers but also to enterprises. For example, they want to know whether sufficient thermal energy arrives at the bore hole to operate a power station with profit. After all, one kilometre of drilling costs easily a million Euro. Of importance are also the estimates as to the risk of the drilling and the fluid forced in during the process causing ground motion.

Professor Dr. Olaf Kolditz and Dr. Uwe-Jens Görke from the Department of Environmental Informatics of the Helmholtz Centre for Environmental Research – UFZ in Leipzig and their colleagues therefore develop computer models simulating such drillings and the operations of a geothermal power station. “We enter into the model the pressure, temperature measured underground as well as other information”, Görke explains. This is augmented by data regarding the fluid forced into the borhole. The model then provides results as to possible deformations in the underground but also information as regards the amount of prospective useable energy and how long the drilling presumably will provide energy before the environment in the depth cools down too much.

COMPUTER MODELS ON GEOTHERMAL ENERGY

The model provides results on possible deformations in the underground, but also information as regards the amount of prospective useable energy.

“Generally, these models are valid for underground transport processes”, stresses Uwe-Jens Görke. Thus with their help not only geothermal power stations can be simulated. They can just as well investigate how the greenhouse gas carbon dioxide behaves deep down, if it is captured in future power stations and forced into subterranean rock formations in order to slow down the climate change. ROLAND KNAUER

UWE-JENS GÖRKE DISCUSSES WITH A PHD STUDENT THE SIMULATION OF A GEOTHERMAL DRILLING, WHICH IS PROJECTED TO THE WALL AT THE UFZ'S VISUALISATION CENTRE. Photo: UFZ/André Künzelmann

Helmholtz Centre for Environmental Research – UFZ

BIOENERGY CAN TURN "BIO"

Energy can be won from maize, rape or other plants, yet the large-scale cultivation of energy plants is not automatically environmentally friendly. "Bioenergy will play a role in many regions of the world, but it will very much depend on how this bioenergy is obtained", says Dr. Daniela Thrän from the Department Bioenergy of the Helmholtz Centre for Environmental Research - UFZ in Leipzig. The UFZ researchers here work closely together with the German Biomass Research Centre (DBFZ) and investigate how the ground and hydrologic balance change through the cultivation of energy plants and how this affects landscapes and their biodiversity. In doing so, they also assess the greenhouse gas balances, evaluate the various exploitation technologies and their markets and devise recommendations for policy makers.

For instance, enormous cultivation areas destroy habitats for animals and plants and in agriculturally used regions biodiversity is lost at an especially fast rate. A solution could be provided by broader strips between fields, offering sufficient retreats for small animals in form of wild plants and trees. And this could entail also a financial benefit, Thrän thinks. For in future, wood will be in even higher demand as a source of energy and in principle, the wild growth at the edges of fields could be mown and also used in biogas plants. For instance, the microbiologists at the Department Bioenergy work on improving the bacterial processes in biogas plants in such a manner as to enable the usage of a wide spectrum of residual plant matter. "It is important that this is achieved not only in high-tech plants such as Bioliq at the KIT, where high-quality fuels are being produced, but that small biogas plants on site can also use residual matter for the production of electricity and heat in an improved way", Thrän explains. In Germany, biological energy sources could cover about 15 percent of the primary energy demand in future, with bioenergy providing advantages over fossil energy sources both in the production of thermal heat and in the utilisation as a fuel.

"However, we model also how the metabolism of the ground, the carbon cycles and water management change through the cultivation of energy plants", explains Thrän. For example, perennial energy plants such as timber or grasses or mixed crops composed of different plants requiring less fertiliser than food plants are advantageous. This is because fertiliser is produced at a high cost of energy and impairs the CO_2 balance of energy plants.

HOW ENVIRONMENTALLY FRIENDLY IS BIOENERGY?

It is important to use more residual matter, save on fertilisers and to observe the regional conditions in order not to pollute both the ground and water cycles.

BROAD STRIPS BETWEEN FIELDS PROVIDE HABITATS FOR WILDLIFE AND PLANTS AND COULD BE ALSO ECONOMICALLY PROFITABLE, SINCE IN FUTURE WOOD AS AN ENERGY SOURCE WILL BE IN GREATER DEMAND. Photo: UFZ

ON CAMPUS NORTH OF THE KIT, THE BIOLIQ PILOT PLANT WILL PRODUCE FROM STRAW AND OTHER RESIDUAL MATTER FIRST AN OIL-LIKE PRE-PRODUCT AND THEN FROM THIS TAILORED DESIGNER FUELS. Photo: KIT

The UFZ researchers around Thrän have developed a consulting tool from which can be derived recommendations as regards the use of certain plants for certain regions and their special grounds and climatic conditions. For instance, maize requires regular precipitation and especially in the middle of Germany it could get significantly dryer over the course of the next decades. “Our research results will contribute to new legal guidelines and funding conditions for the cultivation of energy plants”,Thrän hopes. A uniform solution for all regions will not be possible. It is more important to efficiently use existing residual matter to a greater degree than now and to take the conditions on site into consideration in order to save on fertiliser and not to pollute the ground and hydrologic cycles. If this is the case, then, bioenergy can become much more environmentally friendly. ANTONIA RÖTGER

Karlsruhe Institute of Technology

REFUELLING WITH STRAW

Residual plant matter such as straw or wood shavings can be processed to make high-quality fuels, as researchers from the KIT have shown on a small scale already some years ago. The ecological balance of such synthesis fuels is much better than that of fuels derived from rapeseed oil or other energy plants, for which separate cultivation ground are reserved, fertilised and watered. In cooperation with industry partners such as Lurgi GmbH, MUT Advanced Heating GmbH from Jena and Chemieanlagenbau Chemnitz GmbH, the KIT is building a pilot plant, which is now nearing its completion. The bioliq® process is comprised of several steps: First, the dry biomass is converted into an oil-like intermediary product with high energy density by way of fast pyrolysis in regionally spread out plants. This intermediary product can be easily transported for further processing. In later large-scale plants further steps take place. By way of innovative procedures, some steps could be pooled in the bioliq® pilot plant into one single process step. At the plant, the energy-rich intermediary product is converted into a highly reactive synthesis gas comprised of carbon monoxide and hydrogen molecules with the aid of an entrained-flow gasifier. “These chemical building blocks can be put together in the next step to create any designer fuels one likes”, explains Dr. Nicolas Dahmen, project manager for building the bioliq plant. “The pilot plant will be able to produce 100 litres designer fuel per hour, this is not yet on industrial scale, but allows for encompassing fuel and vehicle tests”, says Dahmen. And those are the precondition for the process finding wider application. ANTONIA RÖTGER

NICOLAUS DAHMEN:
“In the next phase, these chemical building blocks can be put together to produce any desired designer fuels.“

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

Humans influence their environment to a significant extent: Climate change, 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 preventive research. The research regarding Earth and Environment studies the fundamental functions of the system earth and the interactions between society and nature, thereby creating a sound knowledge base for securing the long-term foundations of human life. This is about understanding the complex changes of Earth and Environment in detail and to develop future scenarios so that decision-makers in politics and society are given sound scientific recommendations for their actions.

The diversity of questions calls for the effective 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 extramural research institutions, for example in virtual institutes and also in increased collaboration and cooperation activities at a 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 also contributes to two Excellence Clusters: “The Ocean in the Earth System” (University Bremen/AWI), “Integrated Climate System Analysis and Prediction” (University Hamburg/HZG) and a Graduate School “Global Change in the Marine Realm” (University Bremen/AWI) from the federal government’s excellence competition, which underlines the first-rate cooperation with university partners outside the Helmholtz Association.

The Climate Initiative “Regional Climate Changes” (REKLIM) constitutes a new research alliance. 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. Furthermore, the Climate Initiative 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 featuring strong involvement of university partners is represented in the “Water Science Alliance”, which stra-

tegically focuses the competencies in hydrological research. Cross-centre and cross-institutional research projects at international level are playing an ever more important role in the Helmholtz Association. The Helmholtz Association of German Research Centres and the University of Alberta, Canada intend to cooperate more closely in particular in the research fields Energy and Earth and Environment. For this purpose, the President of the Helmholtz Association, Prof. Dr. Jürgen Mlynek, and the President of the University of Alberta, Prof. Dr. Indira Samarasekera, signed a corresponding "Memorandum of Understanding" in the presence of government representatives on 29 September 2009. The cooperation projected for the next years covers research topics such as the environmentally friendly use of oil sands, the separation and geological storage of CO_2 (CCS), geothermal energy, the reclamation of water bodies and land as well as recultivation and landscaping. Apart from the Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences, initially three more Helmholtz Centres contribute their expertise: the Karlsruhe Institute of Technology, the Helmholtz Centre for Environmental Research – UFZ and the Forschungszentrum Jülich.
Another task for the Research Field is the promotion of young scientists and researchers. The existing measures and structures are continually developed, 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. Currently, two Graduate Schools are sponsored within the research field Earth and Environment ("Helmholtz Interdisciplinary Graduate School for Environmental Research" at the UFZ with six university partners and the "Helmholtz-Graduate School for Polar and Marine Research" at the AWI with three university partners) in addition to the "Helmholtz Research School on Earth System Science" (AWI with two university partners). The number of supervised doctoral candidates reached a record high with 841 in 2009. Furthermore, 15 Helmholtz Young Investigators Groups with reference to the research field are currently being funded.

THE PROGRAMME STRUCTURE
IN THE FUNDING PERIOD 2009-2013

Seven Helmholtz Centres contribute to the research field Earth and Environment: the Alfred Wegener Institute for Polar and Marine Research, the Forschungszentrum Jülich, the Karlsruhe Institute of Technology, Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal 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. The Research Field pools its research activities in four programmes since 2009:

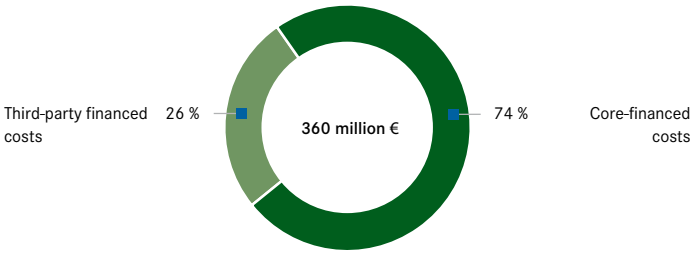
- **Geosystem: The Changing Earth**
- **Marine, Coastal and Polar Systems**
- **Atmosphere and Climate**
- **Terrestrial Environment**

To address superordinate research topics and to create methodological and organisational synergies, additional cross-cut initiatives such as "Climate" (AWI, FZJ, KIT, GFZ, HZG, HMGU, UFZ), "Integrated Earth Observation System" (Network EOS: AWI, DLR, GFZ, HZG, FZJ, KIT) and "Sustainable Bioeconomy" (FZJ, GFZ, HMGU, KIT, UFZ) are further developed.
A further key element is the joint creation and operation of cross-programme infrastructures, such as the research aircraft HALO or the "Terrestrial Environmental Observatories" (TERENO). For instance, 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. A comparable approach is pursued with the Observation System COSYNA, with a long-term observation system being built up initially for the German North Sea and later also for Arctic coastal waters in order to enable a synoptic description of conditions.

"The wise words by Lakota Native American Sitting Bull 'We have not inherited the earth from our ancestors, we have only borrowed it off our children' prophetically committed us to protect our earth and environment as much as possible through precautionary and provisional research and return to our children a sustainable habitat. For this purpose, research alliances such as the Climate Initiative and the Water Science Alliance are ideal platforms for strengthening the competencies of the Helmholtz Centres and their cooperation with national and international partners."

PROF. DR. LIQIU MENG, Senator of the Helmholtz Association, Vice-President of the Technical University Munich

Total costs of the research field Earth and Environment
Actual costs 2009: 360 million Euro
(incl. the share of non-programme-bound research)



THE PROGRAMMES
IN THE FUNDING PERIOD 2009-2013

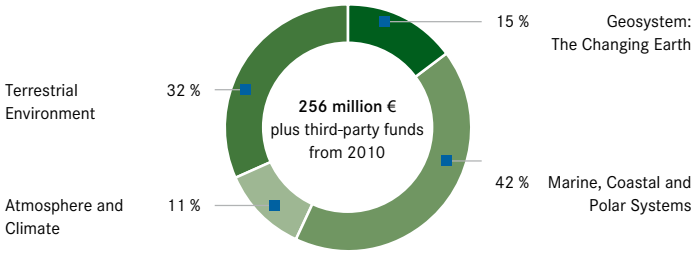
The Geosystem Programme: The Changing Earth

The analysis of the physical and chemical processes within the earth's systems 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 Geosystem 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 are combined into one observation system and integrated into national and international collaborations. The programme focuses on the 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" as well as "Sustainable Use of Resources".

Marine, Coastal and Polar Systems Programme

The research programme has taken on the task of observing contemporary changes in the oceans, polar systems and coastal regions and in particular their assessment against the background of past changes. Regarding the coastal regions, the differentiation between direct human influence and climatic variability is given special consideration. This goal is pursued, for instance, by the development of an encompassing observation system in the German Bight (COSYNA). In the polar regions, the processes governing global climate change as well as the ecosystems' response to change are being studied. The further deciphering of the paleoenvironmental archives in connection with process studies will allow for improved reasoning regarding possible future developments. The aim is the creation of a model system for medium term developments comprising the cryosphere, the oceans and the marine bio- and geo-chemosphere, which will be able to portray biodiversity as well as the flow of energy and matter in different space and time scales. Differentiation between climatic fluctuations and human influences within the complex overall system is to provide the scientific basis for decision making and thus is to support political and social opinion making. Generally, the combination of modern research infrastructures such as measuring stations, ships, aeroplanes and polar stations with mathematical system models are of decisive significance for the goals in view.

Structure of the research field Earth and Environment
Senate recommendation for core-financing 2010: 256 million Euro
(incl. the share of non-programme-bound research)



On the graphs:

The left graph shows the funds actually employed for the research field Earth and Environment during the report year 2009, divided into core-financed and third-party financed costs.

The right graph depicts the core-financed costs approved by the Senate for the year 2010. In addition, the graph shows the distribution of funds to the programmes from the second round of Programme-oriented Funding. A comparison of current numbers with the depictions from the previous years is possible only to a limited degree, since on the one hand, the Helmholtz Centres have undergone repositioning as regards their research fields and programme structure. On the other hand, the onset of the second round of Programme-oriented Funding brings with it a change from differentiated budgeting between R&D and infrastructure costs to absorption costing.

Atmosphere and Climate Programme

The research programme addresses the role played by the atmosphere within the climate system as well as those processes that have a decisive influence on climate changes, natural disasters, air quality and hence quality of life on Earth. Within this context, the behaviour of the stratosphere, troposphere and biosphere and their complex interactions in the global change process are studied. Research priorities include investigations of the hydrological 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 (AIDA, SAPHIR and others) 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 climate changes and to acquire knowledge to inform future actions for the protection against the consequences. Particular emphasis is on the regional level. The new research aircraft HALO will contribute significantly to the success of the programme. It will commence its first missions under fundamental involvement from researchers from this research programme.

Terrestrial Environment Programme

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 for adapting and reducing the vulnerability of our ecosystems. To this end, new technical solutions are designed in the fields of agricultural, bioenergy and environmental technologies. User conflicts at the interface between food production, bioenergy and nature conservation are studied and strategies are developed for adapting to global change at a regional level. Mechanisms regulating the growth of microbes and plants are analysed for a sustainable biomass production system. In the field of water resources systems, a novel ecotechnological approach to protecting and providing water of high quality and sufficient quantity is conceived. A thorough understanding of the processes of groundwater systems and analysis of the vulnerability of groundwater bodies are to enable the assessment of 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 within this progamme.

PROJECTS

Alfred Wegener Institute for Polar and Marine Research

TO THE ARCTIC AND BACK AGAIN: RESEARCH FROM AEROSPACE

Icy frost, massive pack ice and powerful cyclones between polar night and all-day light: The Arctic makes it hard for science to unlock its secrets. For over 25 years now, the Alfred Wegener Institute for Polar and Marine Research (AWI) in Bremerhaven explores the Arctic and Antarctic also from out of the air. In the past year, the German polar aeroplane POLAR 5 departed for a very special Arctic measurement flight. POLAR 5, a modified DC-3, is the latest aeroplane of the polar flying squadron. It took up operations only two-and-a-half years ago. POLAR 5 can fly longer distances and at the same time carry more weight than its predecessors, so that now much more encompassing areas can be explored than was hitherto possible. Furthermore, POLAR 5 features numerous in-situ and remote measuring systems, which can be employed in parallel and for different purposes.
Within the context of the PAM-ARCMIP Campaign (Pan-Arctic Measurements and Arctic Climate Model Simulations), the high flyer took off from Spitsbergen for Alaska in April 2009 and covered a wide, hitherto inaccessible and hence unexplored area. It landed on only two metre thin ice on an ice float at the Russian drift station NP-36. This additional refuelling stop enabled a flight as far as 88° 40´ North, a northern record for POLAR 5. “The mere preparation logistics of the trans-Arctic tour were a major challenge. Without international cooperation, this encompassing project never would have been realisable”, says Dr. Andreas Herber. The AWI physicist headed the project.

ANDREAS HERBER:
“We have found a high degree of aerosol pollution over the entire Arctic with the highest values above Barrow, the northern-most community in Alaska.”

During the measuring flight, 20 scientists and 6 engineers from Germany, Italy, Canada and the USA collected data on aerosols, trace gases, the thickness of marine ice as well as weather data. Aerosols are floating particles such as dust, sand, emissions from traffic or industry, but also large organic molecules emitted by forests. Like water droplets and ice crystals, aerosols have an effect on the climate and so far figure amongst the greatest uncertainty factors in estimating future climate changes.
Sensors register how much the aerosols cloud the atmosphere. “We have found a high degree of aerosol pollution over the entire Arctic with the highest values above Barrow, the northern-most community in Alaska.” Yet where does the Arctic haze come from? According to analysis of the POLAR 5 data, most of it seems to come from the Asian part of Russia, from Northern America and Europe. Weather conditions in early 2009 brought large clouds to the North Pole region and the volcanic eruption of Mount Redoubt one month prior to measurements increased the whole affair.
Furthermore, the campaign rendered for the first time ever also large-scale data regarding the distribution of marine ice in the Arctic. Whereas such measurements usually require an ice thickness probe attached underneath a helicopter, this could be employed for the first time from an aeroplane and this meant that a much larger area could be covered. POLAR 5 lowered the probe on a wire rope and pulled it across the ice surface in twenty metres height. “When combining these data with satellite measurements and model calculations, we obtain another important element in predicting what will happen to the Arctic ice.” The flight revealed ice thickness ranging between 2.5 metres in two-year-old ice in the vicinity to the Pole and 4 metres in several-year-old ice at the Canadian coast. On the whole, the ice was thicker here than in previous years, perhaps it has recovered – temporarily. “The major trend of receding marine ice continues”, Herber is convinced.
Yet in order to be able to make reliable predictions as regards its future, further detailed measurements from the entire Arctic are required. And hence Herber and his colleagues will

THE POLAR 5 FLEW FROM SPITSBERGEN TO ALASKA TO COLLECT DATA ON TRACE GASES AND MARINE ICE THICKNESS. Photo: AWI/M. Buchholz

take off with POLAR 5 again in the spring of 2011: This time, they start from the opposite direction in Alaska, along the Canadian and Greenland coast to Spitsbergen with a detour to the inner Arctic in order to augment and refine the 2009 image. CORNELIA REICHERT

Alfred Wegener Institute for Polar and Marine Research

THE SEA WALNUT ON A CAMPAIGN OF CONQUEST

Glassy and ethereally delicate – Mnemiopsis leidyi, or more popularly the warty comb jelly or sea walnut, looks harmless. Yet appearances are deceiving: At the beginning of the 1980s, the comb jellyfish travelled from the American West Coast as far as to the Black and Caspian Sea in the ballast water tanks of ships. Four years ago, it was also discovered in the Baltic and North Sea. The jellyfish arrived as a voracious conqueror and diminishes the indigenous fish stock. “Fish eggs and larvae are at the top of its bill of fare. Furthermore, it devours zooplankton and thus takes away food from the fish”, says biologist Professor Dr. Karen Wiltshire.
The researcher is Director of the Biological Institute Helgoland (BAH) and is Deputy Director of the Alfred Wegener Institute in Bremerhaven. Together with her colleagues she researches how the stranger behaves in its new habitat and why it spreads with such enormity. For this, the jellies are for the first time caught in a targeted manner and observed in the laboratory. The sea walnut is comparatively robust and survives being caught rather well, yet it still is tricky to simulate the natural sea environment in an aquarium. For instance, turbulences support the jellies in swimming. It is difficult creating just sufficient turbulence to maintain the sea walnut in abeyance, yet little enough not to flush it over the rim.

KAREN WILTSHIRE:
“Fish eggs and larvae are at the top of its bill of fare. It also feeds on zooplankton and thus takes food away from the fishes.”

Observation shows that the jellies are masters of conquest: They can reproduce after only two weeks and in addition they can cope with great differences in salt content and temperature. In their actual tropical home they live in water temperatures of above 25 degrees, here they live with temperatures below 10 degrees even – they only stop at less than 2 degrees. “Previously, the temperature in winter dropped even more. This was the case also this year, but it happens more and more rarely. This, of course, is much in favour of the jelly”, says Wiltshire.
In general, jellies appear more and more frequently in the North Sea – amongst them also predators: The lobed comb jelly (Bolinopsis infundibulum) and the melon jelly (Beroe gracilis), for instance, focus on relatives. Perhaps they keep the sea walnut at bay. It worked in the Black Sea, there, too, a natural enemy appeared. CORNELIA REICHERT

THE COMB JELLY MNEMIOPSIS LEIDYI HAS BEEN INTRODUCED INTO THE GERMAN BIGHT AND THE WADDEN SEA. Photo: AWI/A.Malzahn

SANDSTORMS (HERE IN THE SAHEL SOUTH OF THE SAHARA) DISPERSE PARTICLES, WHICH ARE CARRIED AS FAR AS EUROPE. Photo: CNRS/F. Guichard, L. Kergoat

Karlsruhe Institute of Technology

SMALL PARTS, MAJOR EFFECT

Today, weather forecasts are based on well-developed computer models, yet which still do not take into account many important processes within the atmosphere – for instance, floating particles such as dust, pollen or chemical compounds. Such so-called aerosols not only reduce visibility but influence also the temperature distribution across various altrimetric levels; they can react with one another and as condensation nuclei can cause the formation of clouds and precipitation. Yet in the established models used by weather services, aerosols are included, if at all, only generally because they absorb part of solar radiation. “We now observe the various aerosol particles in much greater depth and model an important part of processes, in particular also the formation of clouds and their interaction with radiation”, explains Dr. Bernhard Vogel from the KIT’s Institute for Meteorology and Climate Research. He and his colleagues have been working for about five years on COSMO-ART, a module with aperture sizes of a few kilometres only, which can be connected to the weather forecasting model COSMO used by the Deutscher Wetterdienst DWD (German Weather Service). The abbreviation ART stands for “Aerosol and Reactive Trace Gases”. By now, COSMO is being used not only by the DWD but also by many other weather services and research institutions in Europe, Canada, Russia and the United Arab Emirates, who are also interested in the ART module.

BERNHARD VOGEL:
“We want to derive from COSMO-ART a regional climate model including aerosols.“

For aerosols are everywhere, they diffuse the light and change transport processes between air layers. Natural aerosols are volcanic ash, sea salt, sand particles from the Earth’s deserts, plant pollen, evaporations from forests or cattle herds. To these are added anthropogenic aerosols such as soot, nitrogen oxides and fine dust from traffic, households and industry. Some particles are only a few nanometres thick, other floating particles measure some hundredths of a millimetre in diameter. “We calculate the concentration of different kinds of aerosols from a set of initial data by way of dispersion calculation”, says Vogel. Thus, information regarding land development, agriculture, forestation, flow of traffic as well as natural and anthropogenic emissions is entered into the model. The modelling itself is based on the knowledge about relevant physical processes and chemical reactions of the different types of aerosols.

Hitherto, the atmosphere researchers tested their model on past periods in time in order to test how realistic the results are. Of particular interest is the question how the concentration of aerosols affects the formation of clouds and thus also the amount of precipitation. For instance, the model shows

how high concentrations of aerosols can delay rain as regards time and location: For high concentrations of aerosols cause countless cloud condensation nuclei amongst which the given amount of moisture is spread out so that the droplets remain floating. Conversely, if there are only few aerosol particles, less but larger drops form, which then rain down.
COSMO-ART can also calculate how sand particles spread across Europe after a sandstorm in the Sahara or which paths the ash takes after a volcanic eruption. By now, the calculated sequences increasingly match the satellite pictures, so that they could be used for prognosis very soon. The pollen forecast for allergic people is almost ready for application, whereas currently it is still painstakingly compiled by hand nearly without computer support. Presently and in cooperation with the KIT, the Deutscher Wetterdienst tests COSMO-ART with a module for birch pollen into which were incorporated locations of birch tree forests; a module for the dangerous ragweed pollen could follow once the locations of the plants are known more accurately. “The United Arab Emirates now also approached us, intending to use an ART module for dust prognosis for aviation”, Vogel states.
Likewise, the usual climate models on regional level are to be incorporated into the ART modules. This is because the interaction between aerosols and cloud formation is badly portrayed in these, with different studies hitherto arriving at contradictory results as to how high concentrations of aerosols can affect climate and precipitation. “In two to three years, we want to create a regional climate model including aerosols from out of COSMO-ART”, says Vogel. “This is an integral contribution on part of the KIT towards the Helmholtz Climate Initiative REKLIM”, explains Institute Director Professor Dr. Christoph Kottmeier. And then one could do a computer test on how stricter critical limits for fine dust, better filters or the cutting down of entire forests affect the regional weather and the long-term climate development. ANTONIA RÖTGER

HZG, KIT, UFZ and AWI

REGIONAL CLIMATE ATLAS OF GERMANY

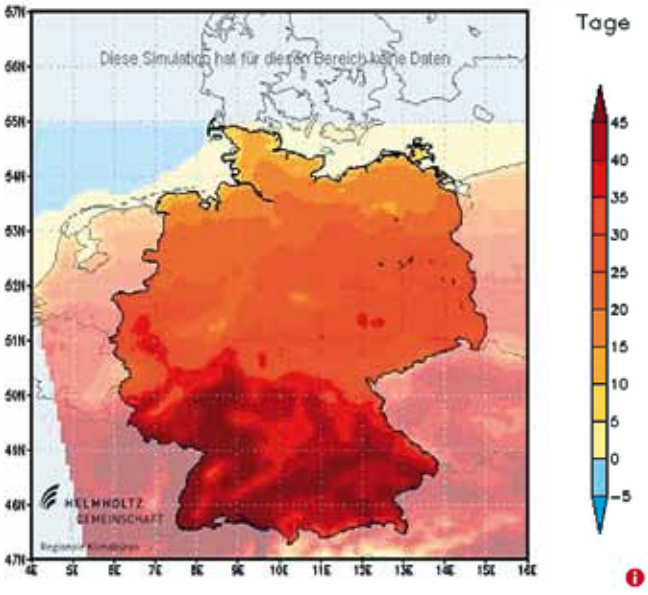
The Regional Climate Atlas of Germany shows how climate change could affect the various regions in Germany during the next few decades by 2100 and was developed by the four Regional Climate Offices of the Helmholtz Association emulating the model of the North-German Climate Atlas.
In Baden-Württemberg it is going to get especially hot and dry in summer and even the annual average temperature could rise by 2.2 to 6.3° C until 2100. “Even now, thermophilic species are on the increase, amongst them also disease carriers such as ticks”, states Dr. Hans Schipper from the South German Climate Office at the Karlsruhe Institute of Technology. In Schleswig-Holstein, the warming until 2100 will be somewhat less, yet precipitation could increase and storms could become more violent there. “A cyclone such as Daisy, which caused heavy storm surges on the German Baltic coast early in 2010, could turn out to be stronger by 10 to 15 kilometres per hour by the end of the century”, says Dr. Insa Meinke, Director of the North German Climate Office

REGIONAL CLIMATE CHANGE

In Baden-Württemberg it gets particularly hot and dry in summer, in Schleswig-Holstein the warming is less intensive and precipitation increases.

at the Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research. The Middle German states Thuringia, Saxony and Saxony-Anhalt have to reckon with dry spells in summer. “This could present agriculture with new challenges”, says Dr. Andreas Marx, Director of the Climate Office for Central Germany at the Helmholtz Centre for Environmental Research – UFZ. The Alfred Wegener Institute for Polar and Marine Research is also involved in the Regional Climate Atlas. The Regional Climate Atlas of Germany is being continuously developed and always includes the current state of knowledge. Thus it offers a scientifically sound basis for citizens, the economy and politics in order to develop climate change adaptation strategies. ANTONIA RÖTGER

UNTIL THE END OF THE 21ST CENTURY (2071-2100), AN INCREASE OF HOT SUMMER DAYS WITH OVER 25 DEGREES CELSIUS IS EXPECTED.
Photo: www.regionaler-klimaatlas.de



METHANE MEASUREMENTS AT A SO-CALLED THAW SLUMP ON HERSHEL ISLAND. THE THAWING OF THE ICE IN THE GROUND LEADS TO THE TRANSPORT OF SEDIMENT TO THE COASTAL AREA. THAWING LIKE THIS COULD BE A SOURCE OF BIOGENIC METHANE. Photo: GFZ/T. Sachs

Helmholtz Centre Potsdam
GFZ German Research Centre for Geosciences

GREENHOUSE GASES BUBBLING UP FROM INSIDE THE EARTH

When Eskimos in Canada light gases, which have accumulated underneath the ice, and have a barbecue on the flame or when the ocean bed resembles an orange peel and features pockmarks of up to several hundred metres in diameter, the same phenomenon makes an appearance: In those regions, methane from the earth's interior escapes to the surface. Some lakes in Canada bubble so intensively then, they seem to be boiling. Yet so far nobody knows what amounts of methane escaped from such sources yesterday, last month or some million years ago. Geoscientists like Professor Dr. Rolando di Primio and Dr. Torsten Sachs from the GFZ therefore ask themselves, how much methane escapes into the air from these and other sources in the earth's interior. For each methane molecule heats up the climate some 25 times more than a carbon dioxide particle.

By contrast, the enormous amount of carbon from which the gas may originate is better known: "The earth's sedimentary basins contain 10 to the power of 16 tons of carbon from organic sources", Rolando di Primio reports. To further illustrate this amount, the geochemist adds a comparison: "This is ten thousand times more carbon than all the coal, oil, natural gas and all organisms on earth combined." This carbon deposit has formed over the course of hundreds of millions of years from dead organisms remaining on the ground or at the bottom of water bodies and which have been covered by other sediments over time. Chemical, physical and biological processes continuously change this gigantic mass and in doing so also create the fossil raw materials mined by modern civilisation as peat, coal, oil or natural gas and burns in power stations and motors. In the process, the greenhouse gas carbon dioxide is released.

However, the fact that by various processes the carbon deposits in the sediments create greenhouse gases such as carbon dioxide and methane also in the earth's interior which then can escape to the surface through cracks and fissures has so far not drawn much attention. When examining the underground with sound waves, they obtain cross-cut sections of the ground. Yet from some areas underneath the surface the method does not render any information, one only sees vertical zones with "white noise". "These are so-called gas chimneys, that is, areas in which methane flows through the sediments in a bundle", explains di Primio. The orange peel ocean bed and the gas escaping from the ground the Eskimos ignite for their barbecues are nothing but leaks in the earth from which this methane escapes.

ROLANDO DI PRIMIO:
"This is ten thousand times more carbon than all the coal, oil, natural gas and all organisms on earth combined."

In Canada's west, geoscientists find so-called tar sands, which originated some 65 to 55 million years ago. The oil contained therein was in part decomposed by bacteria already back then and this process continues to this day, producing large quantities of methane. During the same time, the average temperatures on earth rose to levels significantly exceeding those of today. Since methane is a greenhouse gas, a connection is conceivable. "Yet there are alto-

gether some 500 such sedimentary basins on earth", knows di Primio. Hardly any of these have been examined so far as regards contemporary and previous leaks for greenhouse gases. In any case, in western Canada methane from sediments escapes into the air to this day. In order to understand how much these gases from within the earth influence the climate, the researchers thus intend to examine the sedimentary basins in more detail. "Yet it is difficult to derive from single measurements how much methane may escape into the air from a larger area", explains GFZ researcher Torsten Sachs, who, amongst other things, has researched the methane emissions from the permafrost soils of Siberia.
This problem can be solved by way of a device developed by GFZ researchers in cooperation with colleagues from the Institute of Environmental Physics at the University Bremen. This "Methane Airborne Mapper" or short "MaMap" measures diffused sunlight from the infrared spectrum from out of an aeroplane or helicopter. From a height of a thousand metres, this well over 120 kilogramme heavy spectrometer can determine the methane concentration across areas each 35 metre long and 25 metre wide and thus quickly obtains a relatively detailed image of greenhouse gas emissions also of larger regions. A first test aboard the Polar 5 research aeroplane from the Alfred Wegener Institute went very well. Further flight missions should give Torsten Sachs valuable indicators as regards the amounts of methane escaping from the earth world-wide. And possibly the Eskimos in Canada can soon find new locations for their barbecue evenings with the help of the MAMap data.

ROLAND KNAUER

Helmholtz Centre for Environmental Research – UFZ

EFFICIENTLY PURIFYING SEWAGE

Climate change and population growth lead to an overexploitation of water resources in many regions of the world. UFZ scientists collaborate with colleagues from the TU Dresden and partners from science, the economy and politics within the "International Water Research Alliance Saxony" (IWAS) in order to analyse the regionally specific problems in five hydrologically sensitive regions of the earth. They develop feasible solutions with partners on site, which can also be transferred to comparable regions.
Hence scientists around Professor Dr. Dietrich Borchardt work on concepts for an efficient, decentralised treatment of sewage and sludge in the IWAS model region in northern Mongolia. "Sewage can be reused for the irrigation of fields, if they are free of certain microorganisms", explains Borchardt. For the purpose of testing sewage for bacteria, the IWAS scientists developed a simple procedure based on so-called aptamers functioning as sensor molecules reliably detecting certain bacteria. "We now try to develop the matching aptamer sensors for common bacterial pathogens", says Borchardt. So far, these pathogenes can be detected only under the microscope after a complex sampling. Whereas a simple test procedure could reveal with minimal effort whether sewage can be used already for certain applications. In addition, the UFZ experts further developed a procedure to treat sludge

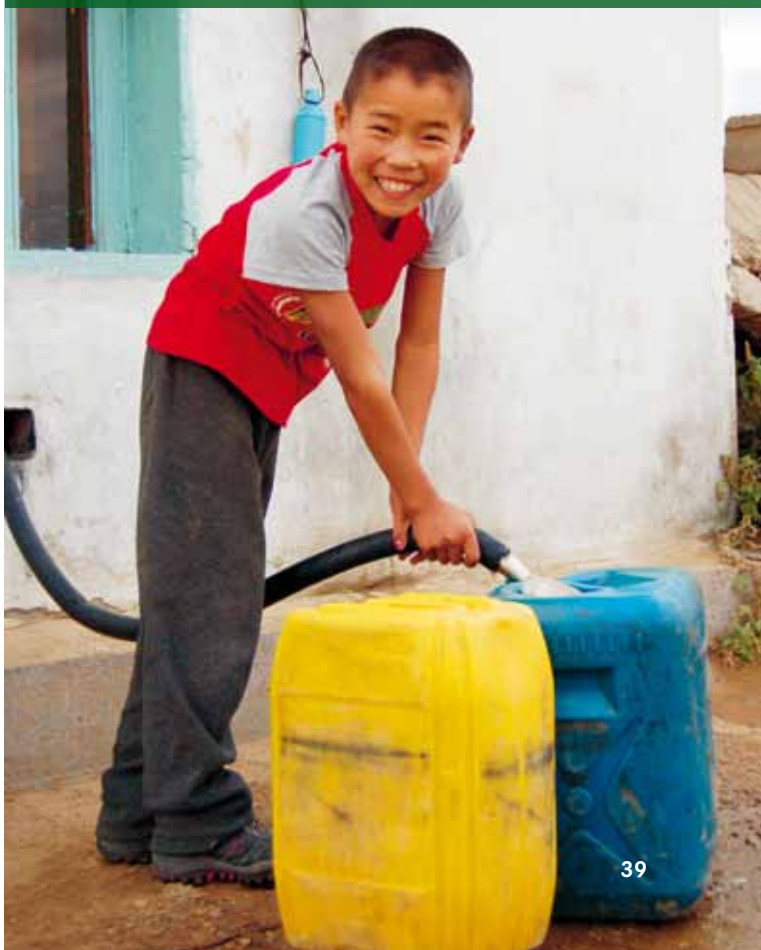
INTERNATIONAL WATER RESEARCH ALLIANCE SAXONY

In five model regions of the earth, the scientists analyse the problems and develop solutions, which can be transferred also to comparable regions.

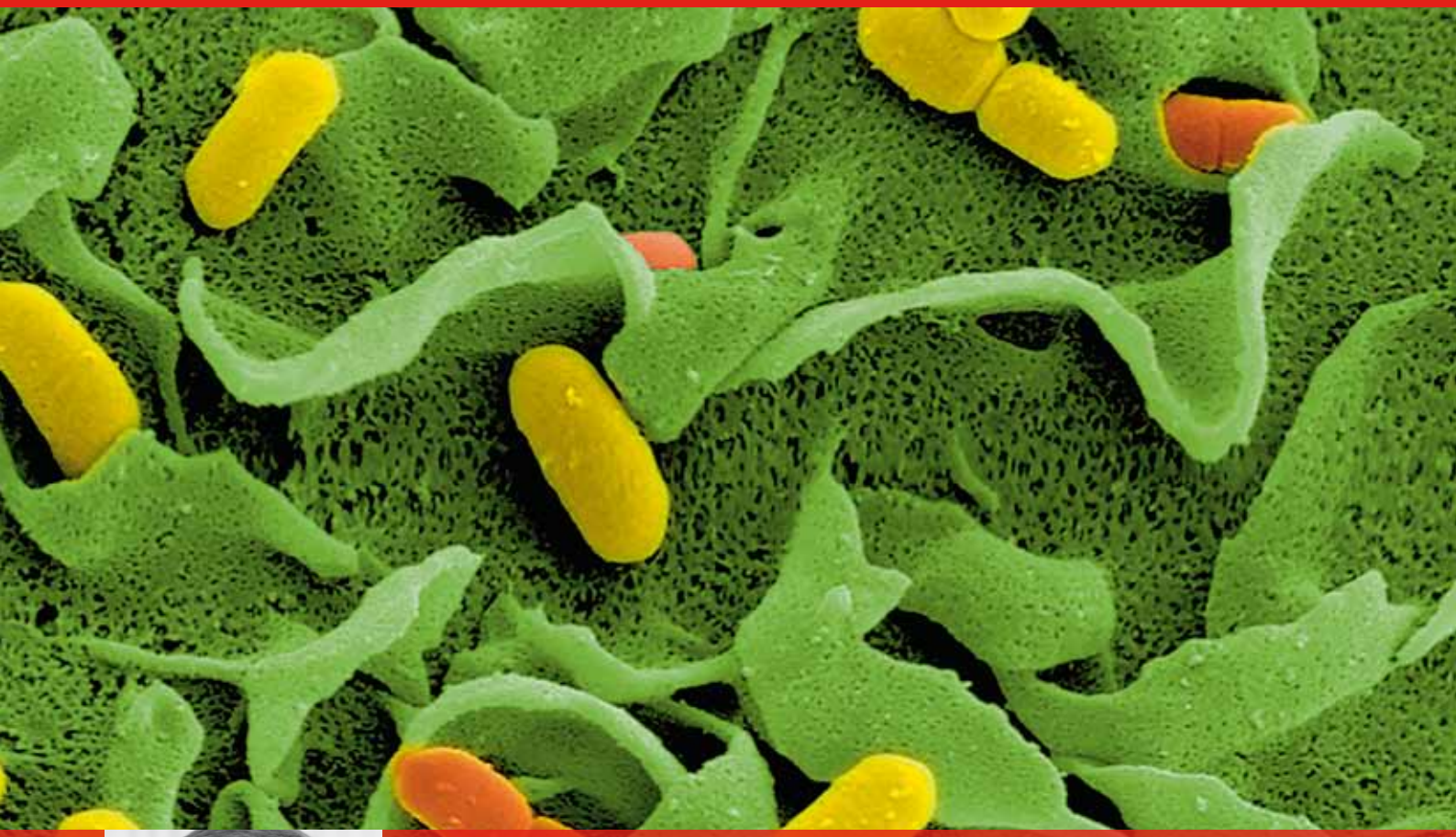
from the liquid waste processing systems. The so-called HTC procedure hydrothermally processes and carbonises the sludge and thus returns it to the cycle as a recyclable material, explains Borchardt. The processed sludge releases nutrients and improves the soil structure so the ground can store more water. "These concepts can be transferred, for example, also to certain regions in the south of Europe, which also suffer from increasing water shortage", explains Elisabeth Krüger from the UFZ, who coordinates IWAS.

ANTONIA RÖTGER

CLEAN WATER IS SCARCE IN NORTHERN MONGOLIA, THEREFORE THE BOY HAS TO WALK TO A WATER KIOSK. Photo: UFZ/L. Horlemann



RESEARCH FIELD HEALTH



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

GOALS AND ROLES

Due to increasing life expectancy and declining birth rates, the percentage of old people in the population continuously rises and poses ever growing challenges to our society and our health system. Chronic common and old age diseases such as cardiovascular and metabolic diseases, cancer, diabetes, lung diseases, degenerative diseases of the nervous system or chronic inflammatory diseases as well as them being influenced by environmental factors and life style continue to grow in relevance and, in addition to research on infectious diseases, stand at the centre of the Helmholtz health research. Scientists from those Helmholtz Centres involved in the research field Health study causes and emergence of these often complex diseases and on this basis develop new strategies for early detection, prevention, diagnosis and therapy.

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. To enable the fastest possible transfer of promising approaches from basic research into clinical application, the Helmholtz Health Centres currently are developing Translation Centres at their sites in close interaction with local partners from university medicine.

Powerful and sustainable structures for networking research competencies of extramural and university health research are

being created for important disease fields. Thus 2009 saw the establishment of the German Centre for Neurodegenerative Diseases e. V. (DZNE) with its core site in Bonn as well as the German Centre for Diabetes Research e.V. (DZD), members of which are the Helmholtz Zentrum München, university partners and institutes from the Leibniz Association. Further centres, amongst them the German Consortium for Translational Cancer Research, coordinated by the German Cancer Research Centre DKFZ, will be put out to tender in 2010.
One of the future key tasks aims to advance German health research by integrating the entire expertise and competence at the Helmholtz Health Centres, university hospitals and other research organisations to create strong strategic partnerships. The biomedical knowledge gain for socially important disease fields is in the foreground and – bundled in consortiums or networks – will yield concrete clinical applications and thus strengthen the German health research with lasting effect and reposition it internationally.

THE PROGRAMME STRUCTURE
IN THE FUNDING PERIOD 2009-2013

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 Association's Health field were jointly reassessed, focused and tailored to the work and objectives of the respectively leading Helmholtz research centre to a greater degree than has been the case so far.
The scientists do research within the following six programmes:

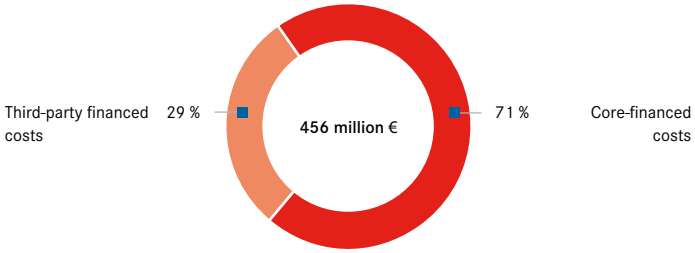
- Cancer Research
- Cardiovascular and Metabolic Diseases
- Function and Dysfunction of the Nervous System
- Infection and Immunity
- Environmental Health
- Systemic Analysis of Multifactorial Diseases

Nine Helmholtz Centres cooperate in these programmes: German Cancer Research Centre, Helmholtz Zentrum München – German Research Center for Environmental Health, Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch, Helmholtz Centre for Infection Research (HZI), German Centre for Neurodegenerative Diseases, Forschungszentrum Jülich, Helmholtz-Zentrum Geesthacht, GSI Helmholtz Centre for Heavy Ion Research as well as the Helmholtz Centre for Environmental Research - UFZ.

"The Helmholtz Association is a nucleus for the development of German Centres for Health Research. In collaboration with university and extramural partners it will thus contribute towards strengthening the research as regards the major common and infection diseases with a lasting effect. In order to meet the major challenges in risk assessment, early detection and prevention of particularly the chronic diseases, the Association furthermore initiated the establishment of the largest German Cohort Study, through which it will create a unique data base for prevention research together with university partners."

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

Total costs of the research field Health
Actual costs 2009: 456 million Euro
(incl. the share of non-programme-bound research;
as well as incl. the costs of the DZNE)



THE PROGRAMMES
IN THE FUNDING PERIOD 2009-2013

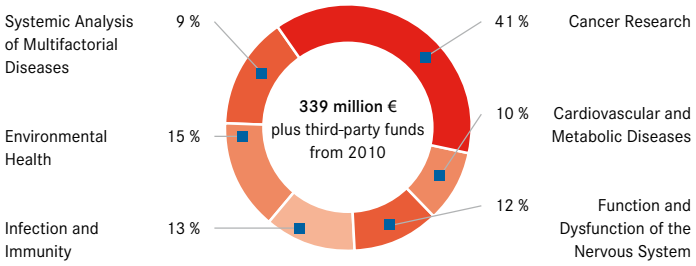
Cancer Research Programme
Some 450,000 people per year in Germany develop cancer. In spite of intensive research activity and numerous fundamentally new developments in this field, more than half the number of patients still dies from the consequences of the disease.
The Cancer Research Programme aims at unlocking the causes and modes of development of cancer diseases. One of the programme's focal points is the development and application of innovative diagnostic and therapeutic procedures based on molecular, cell biological and immunological findings. 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 for more precise diagnoses and therapies, as well as early detection and disease prevention.
The transfer of findings from biomedical basic research into clinical applications is one of the great challenges of cancer research and is to be further advanced by the intensive development of a correspondent infrastructure and strategic alliances. Here, the National Centre for Tumour Diseases (NCT) in Heidelberg has a key part.

Cardiovascular and Metabolic Diseases Programme
Cardiovascular diseases are the most common cause of death in industrialised countries. Major risk factors are high blood pressure, diabetes, increased blood cholesterol, smoking and obesity. To reduce the incidence of these diseases with lasting effect in the long-term, scientists study causes of vascular diseases and high blood pressure, of heart and kidney diseases and of 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 employ various methodological approaches including genetics, genomics and systems biology, cell biology and epidemiology.

Function and Dysfunction of the Nervous System Programme
Longer life expectancy increases the risk of neurological and psychiatric illnesses. The Helmholtz Association's neuroscientific research focuses 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. Scientists use state-of-the-art non-invasive imaging devices to investigate normal and pathologically altered mechanisms in living human brains such as magnetic resonance imaging (MRI), positron emission tomography (PET) and magneto-encephalography (MEG) as well as genomics, cell biology and appropriate animal models.

Infection and Immunity Programme
More than 17 million people world-wide die of infectious diseases every year – this 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. In parallel they analyse the mechanisms of immunity with the aim to develop both new strategies in fighting infection diseases and in immunotherapeutic approaches.
In order to better understand viral or bacterial diseases, which can be transferred from animals to humans (for example, SARS), the zoonosis research will also be further developed in future.

Structure of the research field Health
Senate recommendation for core-financing 2010: 339 million Euro*
(incl. the share of non-programme-bound research)



*plus the DZNE programme under development "Neurodegenerative diseases": 39 million €

On the graphs:

The left graph shows the funds actually employed for the research field Health during the report year 2009, divided into core-financed and third-party financed costs.

The right graph depicts the core-financed costs approved by the Senate for the year 2010. In addition, the graph shows the distribution of funds to the programmes from the second round of Programme-oriented Funding. A comparison of current numbers with the depictions from the previous years is possible only to a limited degree, since on the one hand, the Helmholtz Centres have undergone repositioning as regards their research fields and programme structure. On the other hand, the onset of the second round of Programme-oriented Funding brings with it a change from differentiated budgeting between R&D and infrastructure costs to absorption costing.

Environmental Health Programme

How do environmental factors affect human health? What molecular and cellular mechanisms are at the basis of these disorders and what is the role of genetic disposition in this? Which new preventative and therapeutic strategies can be derived from this? These are key questions within this research programme. The research focuses on common diseases such as inflammations of the respiratory tract, allergies and cancer, the development of which is substantially influenced by environmental toxins such as particulate air-borne pollutants (aerosols), chemicals and ionising radiation. On the one hand, toxic pollutants are researched as well as the corresponding mechanisms triggering diseases with the aim of developing strategies for risk evaluation and reduction. On the other hand, mechanisms of disease genesis of above mentioned diseases are researched to evaluate the role played here by environmental factors. Another emphasis is on basic research on chemical modifications of genetic material.

Systemic Analysis of Multifactorial Diseases Programme

This programme analyses genetic and molecular-biological mechanisms leading to the development of multifactorial diseases via interdisciplinary, joint research platforms in order to find new therapeutic approaches. In doing so, the German Mouse Clinic (GMC) at the Helmholtz Zentrum München plays a central part. The technologies established at the research centre – genomics, proteomics, metabolomics as well as analytics for small molecules and mouse models – offer ideal research conditions for the identification of individual risk factors but also of biomarkers, which can be employed in the early detection of chronic diseases. In doing so, the scientists concentrate on the most essential chronic diseases such as metabolic diseases and diabetes, lung diseases, neurodegenerative diseases as well as disorders of the immune system.

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 further development of important resources and technologies. Here, the fields of epidemiology and translational research are given particular significance as regards research policy and strategy.
Epidemiological research aims at identifying both the genetic and the environmental risk factors so as to prevent diseases or to detect and treat these at an early stage. In order to create a unique resource for epidemiological research, the Helmholtz Health Research has initiated the development of a major prospective national Cohort Study in Germany. The following Centres participated in the initiative alongside university partners: German Cancer Research Centre, Helmholtz Zentrum München, Max Delbrück Center (MDC) Berlin-Buch, Helmholtz Centre for Infection Research, German Centre for Neurodegenerative Diseases and Forschungszentrum Jülich.
The Helmholtz Health Centres adopt a leading role in the field of translational research both nationally and internationally. With the development of local translation centres in cooperation with university hospitals, infrastructure platforms are currently being created, which will decidedly accelerate the transfer of relevant findings from basic research into clinical applications. The formation of strategic alliances with partners from the pharmaceutical industry, biotechnology and medical technology also considerably reinforces the expertise in this field.
The long-term collaboration of Helmholtz Health Centres with partners from university medicine and other research institutions will experience a new dimension with the impending establishment of German Centres of Health Research.

PROJECTS

Helmholtz Centre for Infection Research

CONNECTING STRUCTURAL BIOLOGY AND WOUND HEALING

How do pathogenic agents actually manage to overcome the defence barriers of the human body and attack the organism? The team around Professor Dr. Dirk Heinz at the Department of Structural Biology of the HZI pursues this question. In doing so, the researchers analyse the structures of so-called virulence factors from pathogenic microorganisms by means of x-ray structural analysis, nuclear magnetic resonance spectroscopy and mass spectrometry. Virulence factors are special proteins produced by pathogens that allow them to invade and spread throughout the host cells. “The structural analysis of proteins involved in the infection process is of special importance to us, since the three-dimensional structure of a protein can provide us with information about its actual function”, says Heinz.

STRUCTURAL BIOLOGY AND HEALTH RESEARCH

Insights into the molecular processes during infections could, for instance, help in the treatment of badly healing wounds.

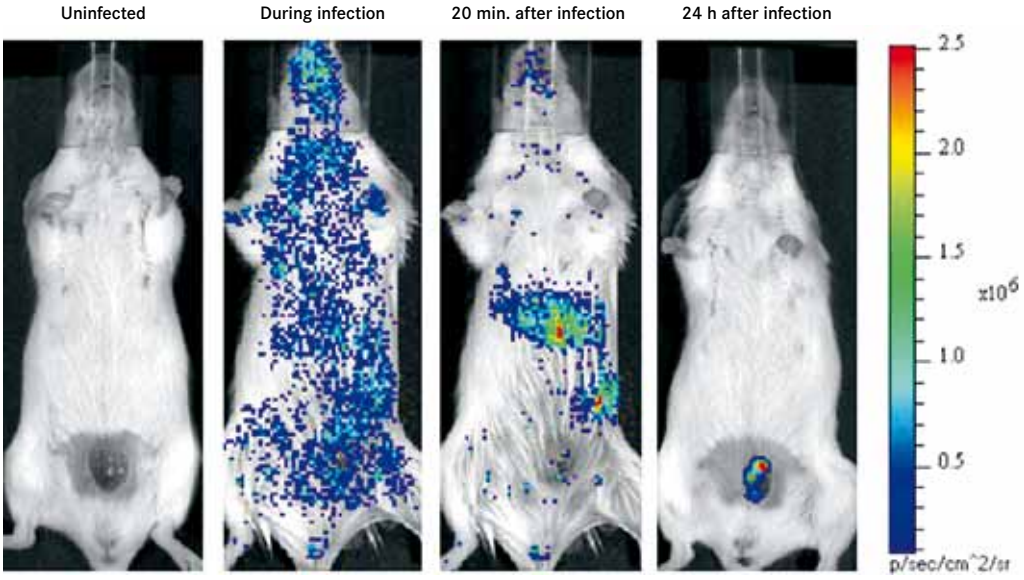
Together with his colleagues he studies the virulence factors of a whole range of human pathogenic bacteria, viruses and fungi. These include the bacterial pathogens, for instance, from Listeria that are found in spoiled food and invade the body via the intestinee. To break through the intestinal barrier, the surface protein internalin A of the bacterium serves as a “key”. It interacts with the protein E-cadherin located on human intestinal cells and adheres to the surface. Subsequently, the bacterium can now invade the organism and spread through the body via the bloodstream.

In contrast to humans, mice are not susceptible to Listeria infections via this route. The HZI researchers have found an explanation for this phenomenon by comparative structural analysis of the E-cadherins from humans and mice: The mouse E-cadherin features a slightly different structure to that of human E-cadherin. Hence, internalin A of Listeria cannot interact with mouse E-cadherin, which is why mice are immune against the intestinal infection with Listeria via the oral route.

Since animal models involving mice play a crucial role in medical research, Heinz and his team have successfully modified the internalin A of Listeria in such a way as to enable it to interact with mouse E-cadherin. Since the structure of mouse E-cadherin was already known, the structural biologists succeeded in producing a Listeria strain that was pathogenic to mice by making two mutations in the Listeria genome. “We do not intend to just analyse structures, but also, if possible to generate new functional knowledge. Through structural biology of the internalins we were able to develop a new animal model for humane listeriosis. In the long term, the results of our research create the basis for the development of new active substances and diagnostics”, says Heinz.

By way of a new study, the HZI researchers provide another important example: Internalin B is a second invasion protein of Listeria. It imitates a growth factor and interacts with the human cell surface receptor Met which, amongst other functions, is involved in wound healing processes. The researchers found that two internalin B molecules artificially linked together cause an increased activation of the Met receptor.

LISTERIA MONOCYTOGENES CAN INFECT HUMAN INTESTINAL CELLS LEADING TO SEVERE INFECTIONS. Photo: HZI/M. Rohde



WITHIN 24 HOURS, SALMONELLAE SPECIFICALLY ENTER INTO THE TUMOUR TISSUE. Photo: HZI

Heinz: “In this form the dimeric internalin B molecule could also positively influence wound healing processes. These results could be of major significance for medical support during wound healing processes - in particular wounds that do not heal well and require intensive treatment. Thus, coming from infection biology we arrive at wound healing – this, too, is possible with insights from structural biology.”
Heinz is convinced that health research profits from structural biology in many ways. Recently, the Department of Molecular Structural Biology of the HZI has become an associated member in the future Europe-wide research network for integrated structural biology infrastructures (INSTRUCT). As a European centre for protein production, the HZI supplies proteins produced using mammalian and insect cells with new technologies developed within the context of the Helmholtz “Protein Sample Production Facility” platform of the institute. Within the Helmholtz Association the HZI is playing a leading role in a new initiative on the site of the campus of the Deutsches Elektronen-Synchrotron DESY in Hamburg-Bahrenfeld. The Centre for Structural System Biology (CSSB) is to be created there to investigate biological structures at high resolution using extremely powerful photon sources.

NICOLE SILBERMANN

Helmholtz Centre for Infection Research

WITH SALMONELLAE AGAINST CANCER

Salmonellae are bacterial pathogenic agents that rapidly proliferate in insufficiently cooked egg dishes in warm weather causing commonly known and infamous consequences. Less known, but no less interesting, is the fact that in addition to ice-cream and egg dishes salmonellae also interact with tumour tissue.

Dr. Siegfried Weiß and his team from the research group Molecular Immunology at the HZI have determined how these bacteria enter into tumour cells. An immune system transmitter enables their access by permeabilizing the blood vessels in cancerous tissue allowing the salmonellae to feed on dead tissue. “They actually consume the cancer from within”, says Weiß. “In mouse tumours this already works rather well, but we want to achieve even more. Genetically changed salmonellae could deliver an active substance from within the tumour cell, which then kills the cancer cells in a targeted manner without impairing the surrounding tissue.”

SIEGFRIED WEISS:
“Genetically changed salmonellae could deliver an active substance within the tumour, which kills the cancer cells without impairing the surrounding tissue.”

However, quite a few obstacles need to be overcome before salmonellae can be used in tumour treatment. “We must not forget that we are dealing with pathogenic agents here. These have to be weakened in order not to inflict damage on the patient. Yet at the same time, the bacteria have to remain sufficiently active to be able to destroy the tumour. Finding this balance – that’s the difficulty”, says Weiß. The HZI researchers have taken up this challenge with considerable determination as they believe the research approach using salmonellae as a weapon against cancer is more than promising.

NICOLE SILBERMANN

German Cancer Research Centre

ON THE PATH TOWARDS AN INDIVIDUALISED CANCER THERAPY

The genome is the genetic material stored within the nucleus of every cell, consisting of a sequence of 3.2 billion DNA building blocks. In 2003, an international research team delivered the completely decoded human genome and thus completed the work on the human genome project begun in 1990. Now, German researchers have joined a new mammoth project of biomedical genome research.

The International Cancer Genome Consortium resolved to reveal the entire range of differences between the genetic material of normal cells and of cancer cells. The goal is a list of all genes the mutation of which advances cancer growth. It is planned to analyse probes from 500 patients each for 50 tumour types. Since the comparison requires also the genetic material sequences of each patient's healthy cells, this results in a total data base of 50,000 genomes, an immense amount of data surpassing anything done in biomedicine to this day. The German Cancer Research Centre (DKFZ) in Heidelberg functions as the central point of contact for the German institutes involved. Professor Dr. Peter Lichter, Head of the Division "Molecular Genetics", is the coordinator of the national research alliance. His deputy Professor Dr. Roland Eils, Head of the Division "Theoretical Bioinformatics", takes on the management of the flood of data.

A project of this magnitude requires international collaboration, for without a doubt it would overextend the financial and personnel capacities of national research. The involved institutes from each country concentrate on one or just a few tumour types each. For instance, the Chinese researchers took over stomach cancer, whereas Japanese and French institutes decided to do one type of liver tumour each. The German researchers are going to analyse two kinds of the most common brain tumours in children, medulloblastoma and pilocytic astrocytoma. Each year, around 300 children in Germany develop this type of cancer. "For these types of tumours there already exist preliminaries and a comprehensive collection of tissue probes at the DKFZ", says Peter Lichter. This project, scheduled to run over five years, receives financial support of 15 million Euro from the Deutsche Krebshilfe e.V. (German Cancer Aid) and the German Federal Ministry of Education and Research. By now, first gene analyses of brain tumour probes have begun within the context of the German "PedBrainTumor" Consortium. New probes are supplied predominantly via a network of German oncologists.

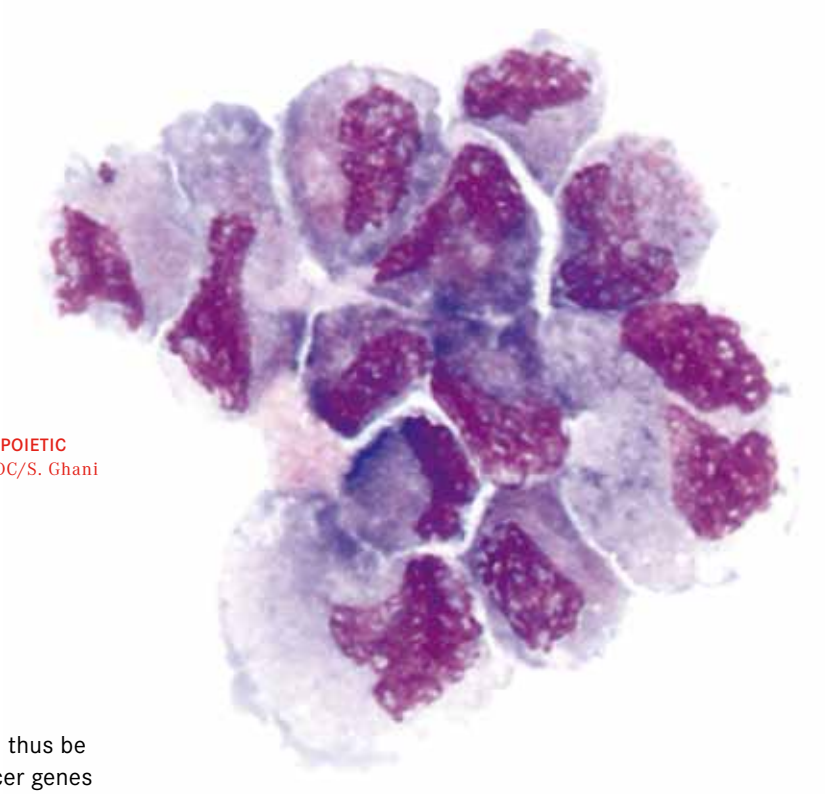
Until recently, cancer researchers assumed that less than ten changed genes are sufficient to effect uncontrolled cell growth. But then first genome analyses of chest and intestinal tumours revealed that in cancer cells at least 20 relevant genes are mutated. The new large-scale project is to find out how many such cancer genes there are – over 300 are known already. Each tumour type could then be characterised by a typical profile of cancer genes and be allocated to a subtype. "Yet this genetic classification aims not to substitute the existing tissue typology but augment it", stresses Lichter. Hence, the complete sequencing of each probe's genome is compulsory. If possible, additional information regarding the gene activities is to be collected. It is also intended to find out, which genes of cancer cells are activated or inactive and what kind of micro RNAs are formed. Micro RNAs are small nucleic acids playing a part in gene regulation.

Cancer patients will directly profit from the research programme's results in various aspects: On the one hand, diagnostics are improved, since the pattern of all cancer genes known by then will reveal the subtype of a tumour in much greater detail than before. At the same time, this facilitates choosing the best suited therapy. For instance, rapidly growing, aggressive forms of tumours call for a different therapy than less dangerous types. On the other hand, the verification of new genetic characteristics of cancer can improve early detection or yield information whether available cancer medication is effective or not. Severe side effects and long-

THE HELMHOLTZ RESEARCHERS INVESTIGATE BRAIN TUMOURS IN CHILDREN, HERE A MEDULLA BLASTULA. MRT image: DKFZ

DECIPHERING THE CANCER GENOME

Cancer patients will directly profit from the results: diagnostics are improved and choosing the best suited therapy is facilitated.



IN VITRO CULTIVATED HEMATOPOIETIC CELLS OF A MOUSE. Photo: MDC/S. Ghani

term consequences of ineffective treatment could thus be avoided. Last but not least, hitherto unknown cancer genes could reveal new target structures leading towards the development of entirely novel forms of medication.
As yet, sequencing the cancer genome for application in routine diagnostics would be too expensive. “The mere running costs for sequencing a genome are between 8,000 and 10,000 Euro these days”, states Lichter. However, it would not be unrealistic for these costs to soon be reduced to under 1,000 Euro. Then each cancer patient could be offered a complete genetic material analysis of his or her tumour. And this would be a great step towards the aim of individualised cancer therapy. JOACHIM CZICHOS

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

DNA METHYLATION CONTROLS BLOOD CELL DECISIONS

Blood cells live only a limited time. Therefore, the body perpetually creates new blood cells. Their reservoir is constituted by the blood stem cells. Depending on a chemical process long known to researchers, a blood stem cell either turns out to be a stem cell again after cell division or various blood cells develop. Now, a research group led by Dr. Frank Rosenbauer of the MDC has discovered that the level of DNA methylation also controls cell fate decision.
During methylation, methyl groups connect with the DNA. Their distribution on the DNA determines which genes are copied and which are blocked. DNA methylation is of great interest to researchers, since it can be influenced – in contrast to genetic information from environmental factors such as diet. Enzymes (methyltransferases) regulate the process.

PRODUCTIVITY OF BLOOD STEM CELLS

The DNA methylation regulates whether blood stem cells turn into stem cells again or into certain blood cells. In contrast to genetic information, it can be influenced by environmental factors.

“For instance, if the enzyme Dnmt1 is missing, the blood stem cells are defect and the affected mice die”, explains Rosenbauer. When blood stem cells produce some Dnmt1, they survive, but the stem cells lose thei,r potential for self-renewal, and only certain blood cells are created.
Cancer stem cells likewise hardly renew themselves when DNA methylation is very low. In this case, they then also develop less well into leukaemia cells. The MDC researchers now intend to find out why cancer stem cells can be inactivated by a Dnmt1 blockage. BARBARA BACHTLER

THE GENOME ANALYSIS CENTER AT THE HELMHOLTZ ZENTRUM MÜNCHEN PROVIDES MODERN TECHNOLOGIES FOR GENOME, PROTEOME AND METABOLOME ANALYSIS. Photo: Helmholtz Zentrum München

Helmholtz Zentrum München – German Research Center for Environmental Health

METABOLOMICS – KEY TOOL FOR DIABETES RESEARCH

The risk for diabetes or other metabolic diseases increases enormously, when unhealthy eating habits and a lack of exercise coincide with genetic disposition. Researchers of Helmholtz Zentrum München discovered variants of known diabetes risk genes and other genes, which for the first time they could definitely link with lipometabolism disorders. Their research results contribute towards a better understanding of the disease and the development of diabetes and could also enable the development of new approaches for early diagnosis and therapy. Professor Dr. Karsten Suhre of the Institute of Bioinformatics and Systems Biology at Helmholtz Zentrum München works in the new field of metabolomics. He and his colleagues are studying the composition and concentration of the body's metabolic products, the so-called metabolites. The composition of metabolites is dependent on a person's genetic makeup. For instance, persons with other variants of diabetes risk genes also display a corresponding different composition and activity of enzymes encoded by these genes. And this has a direct impact on the concentration of metabolites in the serum. Different metabolic profiles are also called metabotypes. A human being's metabotype hence depends on genetic disposition and is influenced by diet and life style.

Against this background, the team of researchers led by Karsten Suhre together with Dr. Christian Gieger, Dr. Thomas Illig and Professor Dr. Jerzy Adamski of Helmholtz Zentrum München studied the concentration of more than 150 metabolites in blood samples from 1,800 participants in the population study KORA. KORA stands for "Cooperative Health Research in the Augsburg Region" and is headed by Professor Dr. Dr. H.-Erich Wichmann, Helmholtz Zentrum München. The metabolic profiles were compared and correlated with the genetic variants of the KORA subjects. For the first time, the Helmholtz researchers could demonstrate with their study a direct connection between gene variants and differences in metabolism. "The link between genetics and metabolites is new and decisively advances our search for markers for the early detection and therapy of severe metabolic diseases such as diabetes", says Karsten Suhre. "In the future, an identification of genetically determined variations in the metabolism can contribute towards the individual prediction of risk regarding certain diseases, reactions to drug treatment as well as dietary or environmental influences."

KARSTEN SUHRE:
"This research brings us closer to identifying markers for the early detection and therapy of metabolic diseases such as diabetes."

The results from metabolomics research illustrate the physiological effects of specific gene variants. “Metabolomics will help determine health risks for certain diseases in a much more differentiated manner than has been possible thus far with gene analysis – in particular for diseases closely connected with the metabolism”, says Karsten Suhre. Amongst these are common diseases such as diabetes, gout or constriction in the coronary arteries often leading to stroke or heart attack. Suhre: “With this knowledge, patients can be treated in a more targeted manner in future, because their reactions to medication and also the influence of diet and environment can be classified more precisely. Our research results are a first step towards individualised medicine and diet.” NICOLE SILBERMANN

German Cancer Research Centre

BROWN BODY FAT AS A WEIGHT LOSS PRODUCT

Usually, metabolic regulation ensures energy balance so that the body weight remains fairly stable. In the event of increasing obesity, more energy is deposited in the so-called white adipose tissue than is used. By contrast, brown adipose tissue has a different function, converting energy into heat. The idea is, therefore, that brown adipose tissue could possibly help to restore the disturbed balance between absorption and consumption of energy.

Researchers from the Division of Molecular Metabolic Control at the German Cancer Research Centre headed by Dr. Stephan Herzig discovered a signal path in mice triggering the new formation of brown adipose tissue. The inflammation enzyme Cyclooxygenase-2 (COX-2), which regulates the production of prostaglandins, has a decisive part in this process. In genetically altered mice producing the enzyme in excess quantities, the prostaglandin level rose and effected that progenitor cells in the white adipose tissue developed into brown adipocytes. These mice weighed some 20 percent less than normal animals and remained slim even when given a fat-rich diet. The Heidelberg researchers consider the possibility of using the production of brown adipose tissue for treating obesity. “There are calculations according to which 50 grams of additional brown adipose tissue increase a person’s metabolic rate by 20 percent”, says Herzig.

STEPHAN HERZIG:
“There are calculations according to which 50 grams of additional brown adipose tissue increase a person’s metabolic rate by 20 percent.”

However, tumour patients suffering from cachexia could also profit from the new research results. A study showed that treatment with COX-2 inhibitors halts the excess energy consumption and the ensuing emaciation. JOACHIM CZICHOS

GENETICALLY ALTERED MICE PRODUCING THE INFLAMMATION ENZYME COX-2 IN EXCESS REMAIN SLIM COMPARED TO NORMAL MICE EVEN WHEN GIVEN A FAT-RICH DIET.
Photo: DKFZ

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

MOUSE AS A MODEL FOR STROKE PATIENTS

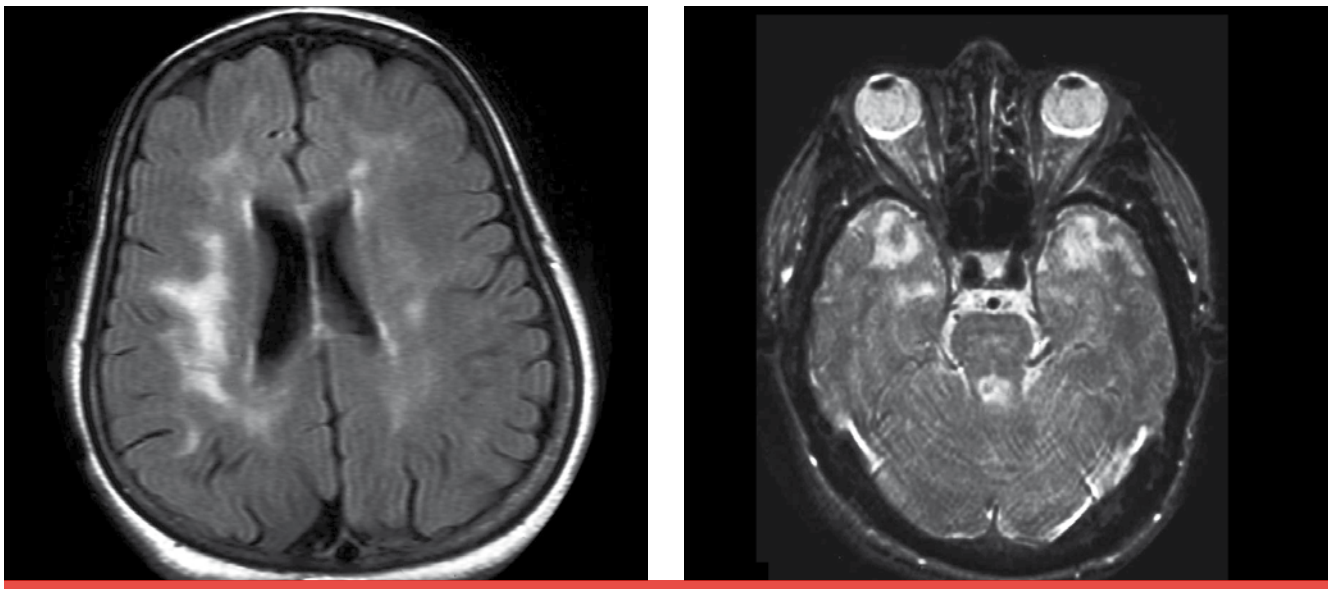
Some 250,000 people per year in Germany sustain a stroke. The majority of people affected then suffer from consequential damages such as paralysis and language or vision disorders. In collaboration with French colleagues, researchers led by Professor Dr. Norbert Hübner of the MDC have now developed a mouse model enabling the detailed study of risk factors for stroke development. In doing so, the researchers based their work on the hereditary disease CADASIL (Cerebral Autosomal Dominant Arteriopathy with Subcortial Infarcts and Leukoencephalopathy). CADASIL can lead to a form of stroke affecting in particular the smallest blood vessels. In contrast to the classic cerebral infarct, frequently caused by arteriosclerosis, CADASIL is linked to changes in a gene called "Notch 3". CADASIL is amongst the most frequent genetically caused cerebral infarcts, yet is considered one of the rarer diseases: Some four people out of 100,000 inhabitants are affected. An early symptom is a migraine-like headache, caused by the characteristic constriction of vessels. Over the years, transient ischaemic attacks or strokes occur repeatedly, ultimately leading to a decrease in mental performance and even dementia. So far, there is no effective treatment. To prevent those "mini" strokes, it is recommended - in addition to medication with acetylsalicylic acid - to minimise risk factors and maintain parameters such as blood pressure, blood sugar and blood lipids within the optimal range.

Even so, CADASIL plays an important role in medical research: "It has model character for other epidemiologically significant diseases such as microangiopathic stroke, where the smallest blood vessels are constricted, or vascular dementia, where the blood flow in the brain is impaired. Due to similar pathology, we can learn much from this specific disease", says Hübner.

The MDC researchers could successfully insert an altered human Notch 3 gene into a mouse by way of an artificial chromosome. In order to accomplish this, they built the altered Notch 3 gene into an artificial circular chromosome (plasmid) and inseminated egg cells of mice with this via microinjection. Since it cannot be controlled where the new genetic material is inserted into the mouse's genome, Hübner and his team also inserted the large regulatory areas to the left and right of the Notch 3 gene into the plasmid. These regulatory areas are essential for Notch 3 being copied correctly and to the normal degree.

The experiment which the MDC researchers conducted for the first time for the CADASIL disease, was successful: The gene was built into the mouse genome and the genetically altered animals developed a whole series of preliminary stages of the disease also occurring in humans. Constriction and

NORBERT HÜBNER:
"CADASIL has a model character for other epidemiologically important diseases such as stroke or dementia."



MDC RESEARCHERS INVESTIGATE THE HEREDITARY DISEASE CADASIL ON A MOUSE MODEL. SOME 4 OF 100,000 PEOPLE SUFFER FROM THIS DISEASE. THESE MRT IMAGES OF CADASIL PATIENTS (HERE FROM THE KING FAISAL HOSPITAL, SAUDI ARABIA) SHOW SMALLER INFARCTS.
Photo: King Faisal Specialist Hospital, Riyadh, Saudi Arabia/K. Abu-Amero, S. Bohlega

DR. FRANCESCA ALESSANDRINI INVESTIGATES HOW PARTICULATE MATTER CAN INFLUENCE ALLERGIC REACTIONS. Photo: Helmholtz Zentrum München

blockage of small blood vessels did indeed occur, resulting in stroke and deteriorating mental performance. “With these results – in addition to cell biological studies – it now at last is possible to simulate microangiopathic diseases in animal models. We can now research why this disease actually occurs in humans and test whether there are other risk factors beyond those known so far and in what measure these actually lead to the development of stroke”, says Norbert Hübner. “And, of course, our research also focuses on how it can happen in the first place that the mutation in the Notch 3 gene leads to stroke in CADASIL patients and how this can be prevented in future.” NICOLE SILBERMANN

Helmholtz Zentrum München – German Research Center for Environmental Health

ULTRAFINE PARTICLES AGGRAVATE ASTHMA

Exposure to particulate matter often leads to aggravation of allergic asthma. This association has already been established by epidemiological studies. However, Dr. Francesca Alessandrini and her colleagues from Helmholtz Zentrum München and from the Centre of Allergy & Environment (ZAUM) at Technische Universität München wanted to investigate the role of ultrafine particles more exactly. In their study, they worked with allergic (sensitised) mice that had first inhaled ultrafine carbon particles like those contained in diesel soot. Then the animals were exposed to specific allergens. The researchers studied the allergic reactions such as mucus production in the respiratory tract and the animals’ inflammatory reactions. Those mice previously exposed to particulate matter reacted much more strongly than a group of control mice that were likewise exposed to allergens but not to ultrafine particles.

ULTRAFINE PARTICLES AND ALLERGY

Mice that had been exposed to particulate matter reacted more strongly to allergens than non-exposed mice.

This effect was all the greater, the higher the particulate exposure level and the shorter the subsequent interval to allergen exposure. The researchers were able to show an increased allergic reaction compared to the control animals even after an interval of four days between particulate inhalation and allergen exposure. “Our findings support the assumption that allergic (sensitised) people are likely to react more strongly to ultrafine particles than non-allergic (non-sensitised) people”, explains Francesca Alessandrini.

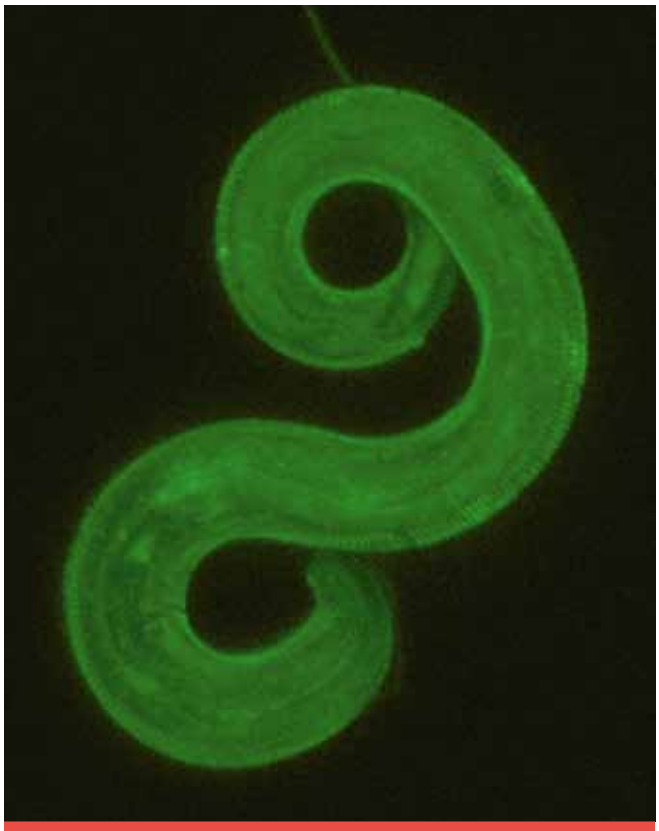
NICOLE SILBERMANN

German Centre for Neurodegenerative Diseases (DZNE)

TIME LAPSED AGING

As life expectancy increases more individuals retain good health lfor a longer time. However, also the risk of cancer, cardiovascular and neurodegenerative diseases increases with age. Today, neurodegenerative diseases take a significant toll as cause of death in old age. In Germany around one million individuals are affected by dementia. This number could triplicate by 2050. There is a fine line between healthy and pathological ageing and understanding the factors that control the ageing process is key to improve life quality for old individuals . At the DZNE in Bonn, Dr. Daniele Bano leads the “Aging and Neurodegeneration” research group. He and his team are researching the genetic causes and physiological mechanisms of aging processes to understand how neurodegenerative diseases develop.

In recent years, research projects have shown that aging weakens the connections between nerve cells. This loss of connectivity appears to be the cause of memory impairment in neurodegenerative diseases. Bano and his team are therefore working on identifying genes that could put a stop to this aging process in the brain. The test subject they selected is the Caenorhabditis elegans nematode, a tiny roundworm, less than a millimetre long, which has a life expectancy of just three weeks. It enables DZNE scientists to observe this accelerated aging process and obtain results far more quickly than with mice, which have a much longer life span. Nematodes are also more cost-effective, easier to breed and simpler to genetically manipulate. Some of the genes controlling aging in humans and worms are actually very similar. “We can perform basic genetic tests on roundworms to identify genes that are likely to play an important role in brain structure or neuronal physiology,” says Bano. “We then test those genes on higher life forms such as mice, to allow us to better transfer the results to humans.”



OBSERVING THE CAENORHABDITIS ELEGANS NEMATODE AGE IS LIKE WATCHING SPED-UP FILM. Photo: DZNE

DZNE EXPERIMENTS ON WORMS AND MICE:

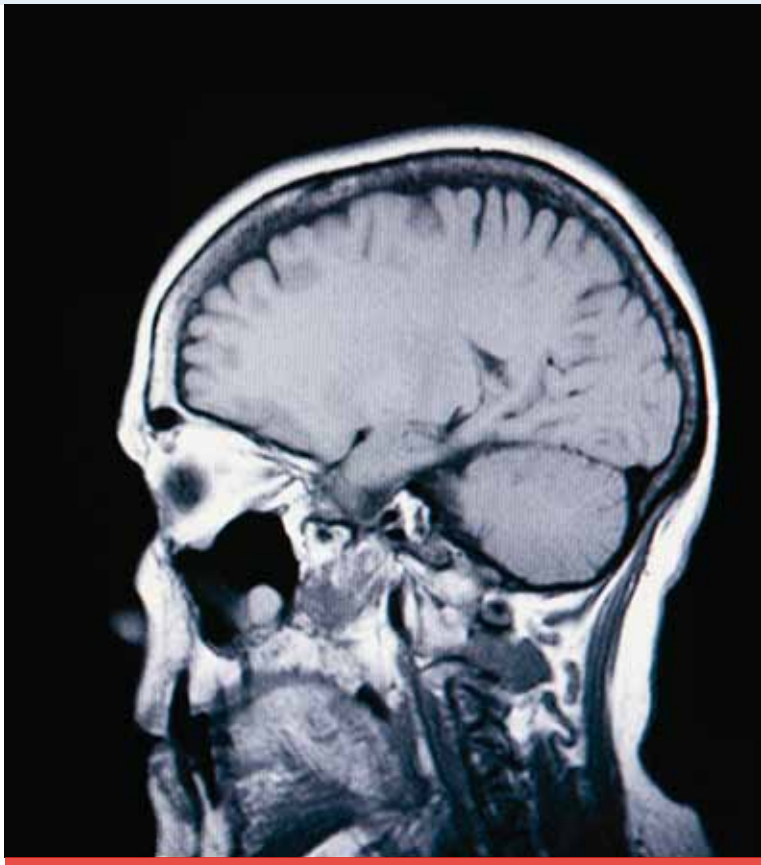
Does slowing the aging process also postpone the onset of age-related learning difficulties?

Roundworms live much longer than other worms, so the scientists are carrying out tests to pinpoint the genetic variations responsible for this. A variety of experiments using genetically modified test subjects allow the DZNE team to observe how the worms’ genetic make-up affects the aging process. The work involves targeting specific genes associated with the aging process and manipulating them so as to either accelerate their function, decelerate it, or turn it off entirely. Bano explains that his team is also examining what metabolic processes these genes are involved in and what role these processes play in human aging. “Today we know that metabolic changes in old age play a major role in causing nerve cells to malfunction and degenerate, which leads to neurodegenerative disease. However, we do not yet know exactly why that happens,” he says.

Dr. Dan Ehninger’s research group is also exploring what impact aging has on neurodegenerative diseases. Since February 2010, Ehninger has led the “Molecular and Cellular Cognition” Young Investigators Group. He plans to build on the findings with the nematodes, using mice to understand the effects of aging and to explore how behaviour, learning and memory change as we get older. To gain this insight, Ehninger and his team will artificially delay the aging process in the mice.

Mice live longer when they are fed rapamycin, an immunosuppressant drug used in organ transplants. It affects the mTOR enzyme, which performs a variety of signalling and metabolic functions and is responsible for aging processes. While mTOR stimulates the production of proteins, it also inhibits catabolism within cells. Rapamycin intervenes in these metabolic functions, and in animal models of Alzheimer’s, the drug was found to significantly delay the onset of the

disease. “We want to find out exactly why it prolongs life and slows the onset of disease. Obviously, we are also interested in how slowing the aging process affects brain aging and whether it can also postpone age-related learning difficulties,” says Ehninger.
Tests will examine how active Alzheimer’s genes combined with rapamycin affect both young and old mice. The researchers hope to find out how age affects the progress of the disease and whether different effects occurring in the brain could have an impact on the ability to learn. Ehninger explains that his group’s research activities will focus on the links between aging and neurodegeneration. “One of the questions we hope to answer is why neurodegenerative diseases usually appear at such a late stage. And of course we want our research to play a part in developing new therapeutic approaches through gaining a better understanding of neurodegenerative processes.” NICOLE SILBERMANN



IMAGING TECHNIQUES REVEAL STRUCTURAL CHANGES IN THE BRAIN THAT OCCUR IN PATIENTS SUFFERING FROM ALZHEIMER’S, FOR EXAMPLE. Photo: iStockphoto

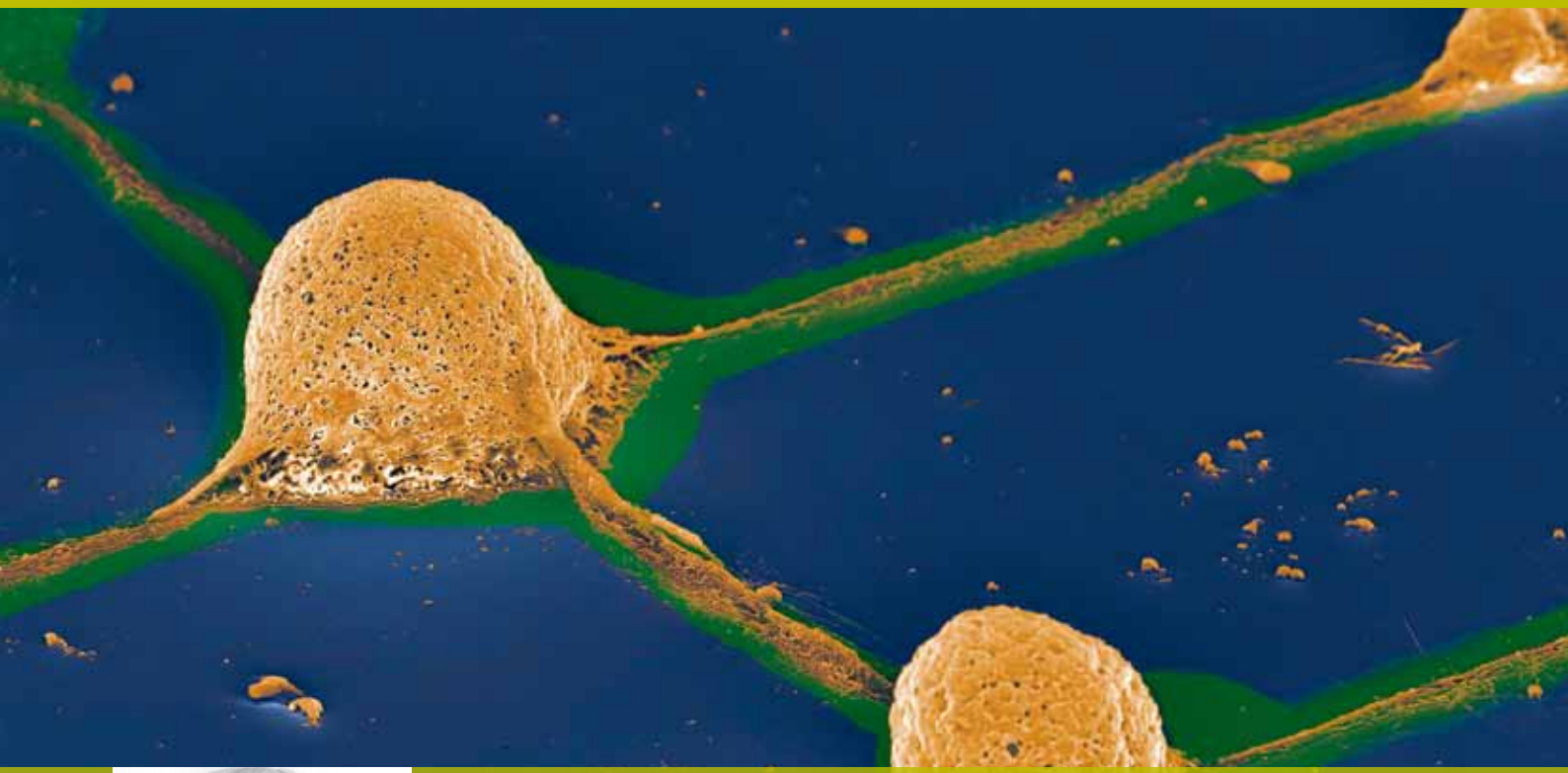
German Centre for Neurodegenerative Diseases (DZNE)

EARLY WARNING SYSTEM FOR NEURODEGENERATIVE DISEASES

When they have trouble remembering something, many older people ask themselves whether it is just old age making them a little forgetful, or whether it is a sign of the onset of dementia. Medical imaging technology such as magnetic resonance imaging (MRI), which visualises structural or molecular changes in the brain, can diagnose the causes behind such memory blips – but a negative result can give patients a false sense of security, as not all changes can be detected. The technology is also not yet able to distinguish between various subtypes. “At the moment, it is becoming increasingly clear that there is only a very small time frame in which preventive therapy can be effective and that, where possible, patients should begin treatment before symptoms appear,” says Prof. Pierluigi Nicotera, Scientific Director of the German Center for Neurodegenerative Diseases. “What we need is a predictive diagnosis of potential dementia, and other processes to help predict the further course the disease will take.” The DZNE is thus working on a method of diagnosis that can detect different types of dementia at an early stage and predict how the disease will develop. The researchers are concentrating particularly on neurochemical and molecular changes that take place in the brain long before structural damage becomes apparent. Substances known as biomarkers indicate these changes. The scientists are currently measuring the levels of two biomarkers – tau proteins and amyloid-beta peptides – in patients’ cerebrospinal fluid. This means that patients with a mild cognitive disorder can be diagnosed with Alzheimer’s at least six years before the disease manifests itself – even if the findings of the MRI were negative. But this just represents the very beginning of an early-warning system for dementia. “The cerebrospinal fluid method is still an invasive process,” explains Prof. Nicotera. “We have to find an inexpensive, automated way of detecting the presence of biomarkers in the blood. To do this, we need to identify new biomarkers.” He says that this could happen in as little as five years. Researchers are to observe patients with mild brain disorders over a longer period of time, conducting tests to identify neurochemical markers of dementia in the blood and cerebrospinal fluid, and running high-resolution 7 Tesla MRT (including functional MRI) and positron emission technology (PET) scans. The short-term goal is to slow the onset of neurodegenerative diseases, preventing them from becoming actual dementia until years later. The long-term goal is to stop dementia – which has such a devastating impact on the lives of sufferers and their families – from taking hold at all. SONJA JÜLICH-ABBAS

PIERLUIGI NICOTERA:
“We have to find an inexpensive, automated way of detecting the presence of biomarkers in the blood. To do this, we need to identify new biomarkers.”

RESEARCH FIELD KEY TECHNOLOGIES



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

GOALS AND ROLES

In the research field of Key Technologies, scientists of the Helmholtz Association predominantly work on generic technologies with their promise of new methods and innovative solutions as regards the great challenges our society faces. The special large-scale research specific infrastructure of this research field can promote fast industrial application. In particular, this includes work in areas such as Nano electronics, nanotechnology, 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 the simulation of complex systems and testing of hypotheses, 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. Thus Nobel Laureate Peter Grünberg illustrated with the detection of the GMR effect, how results from research can be translated into future key technologies, which lead to innovative products with high economic and industrial relevance within 10 – 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. An especially 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 and is strongly supported by modelling and simulation. Helmholtz-specific technology platforms cooperate closely in this together with select 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 Jülich Supercomputing Centre (JSC) with multi-petaflop performance has been firmly established as part of the German Gauss Centre for Supercomputing and as an architect of the Partnership for Advanced Computing in Europe (PRACE). JSC's unique supercomputer infrastructure is offered through PRACE to all scientific research communities in Europe. The research field supports the German federal government's high-tech strategy, specifically in the fields bio- and nanotechnology, micro- and Nano electronics, optical technologies, microsystem and materials technology as well as information and communication technology. 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.

THE PROGRAMME STRUCTURE
IN THE FUNDING PERIOD 2010-2014

The research field Key Technologies was 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 (p. 16f).

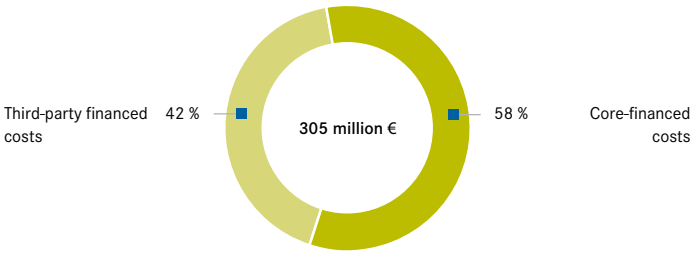
- Supercomputing
- Fundamentals of Future Information Technology
- NANOMIKRO: Science, Technology and Systems
- Advanced Engineering Materials
- BioSoft: Macromolecular Systems and Biological Information Processing
- BioInterfaces: Molecular and Cellular Interactions at Functional Interfaces
- Technology,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

This work is characterised by close cooperation with the 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, they are used for cooperations across programmes. The research fields Energy, Aeronautics, Space and Transport, Health and Earth and Environment also benefit from work on the key technologies.

"Developments in the field of Key Technologies show the potential of the Helmholtz Association to address important problems of our common future. Impressive capabilities of supercomputing, for example, enable reliable simulations of very complex processes in unprecedented detail."

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

Total costs of the research field Key Technologies
Actual costs 2009: 305 million Euro
(incl. the share of non-programme-bound research)



THE PROGRAMMES
IN THE FUNDING PERIOD 2010–2014

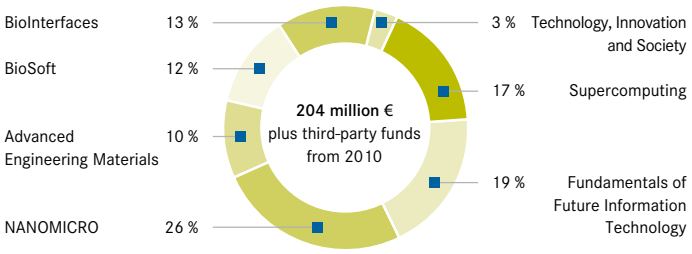
Supercomputing Programme
The processing of large volumes of data and the modelling of complex systems are important research activities. By focusing on supercomputing and grid computing, this programme provides science in Germany with indispensable infrastructures. At the Jülich Supercomputing Centre and the Grid Computing Centre Karlsruhe, experts work on optimizing methods, tools and applications, and provide support for numerous internal and external users from various research fields and institutions. This research programme also aims to develop and operate the latest and most powerful generation of supercomputers; JUGENE in Jülich is the fastest computer in Europe. 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.

Fundamentals of Future Information Technology Programme
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 present-day knowledge, 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. Research within this programme therefore studies quantum electronic, magneto-electronic, ferroelectric, redox-switching and molecular nanostructures. Ultrahigh-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.

The NANOMICRO Programme: Science, Technology and Systems
While microsystem technologies are already in use in a broad range of applications, nanotechnology still requires extensive basic research. In this programme, new functional microsystem structures made from plastics, metals or ceramics are developed and the application potential of nanostructured materials in such structures is examined. Components are developed for micro-optics, micro-process engineering, microfluidics and the life sciences – often in cooperation with industry. Reliable process technologies are developed which enable the industrial manufacture of nanostructured materials with tailored properties. Nanomaterials and processes constitute the core of the programme, while optics and photonics are the emerging fields of application. Another focus is on materials for energy storage, in particular for batteries in electrical vehicles. The broad scope from knowledge oriented research to application-oriented system will allow the translation of basic research into applications. The central technical installations within the programme are available to the "Scientific Community" by way of the Karlsruhe Nano Micro Facility with access open to national and international users.

Advanced Engineering Materials Programme
This programme develops novel metallic and functional polymer-based materials for lightweight construction in transport and energy technology, for chemical process engineering, for future hydrogen technology and for medical technology. Helmholtz scientists collaborate with national and international partners from science and industry on issues associated with alloy and polymer development and processing, as well as the development and testing of components and processes. The functionalisation of magnesium and titanium alloys for the application in biocompatible implants constitutes a new focal point. Research is conducted on material characterisation and simulation techniques from the materials microstructure to the level of complex components. This delivers the theoretical foundations for optimising materials processing and for evaluating the

Structure of the research field Key Technologies
Senate recommendation for core-financing 2010: 204 million Euro
(incl. the share of non-programme-bound research)



On the graphs:

The left graph shows the funds actually employed for the research field Key Technologies during the report year 2009, divided into core-financed and third-party financed costs.

The right graph depicts the core-financed costs approved by the Senate for the year 2010. In addition, the graph shows the distribution of funds to the programmes from the second round of Programme-oriented Funding. A comparison of current numbers with the depictions from the previous years is possible only to a limited degree, since on the one hand, the Helmholtz Centres have undergone repositioning as regards their research fields and programme structure. On the other hand, the onset of the second round of Programme-oriented Funding brings with it a change from differentiated budgeting between R&D and infrastructure costs to absorption costing.

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 hydrogen in tank systems based on lightweight metal hydrides. The results will then be used, for example, for energy storage by hydrogen in wind power stations or for solar energy, as well as for mobile tank systems in vehicles.

BioSoft Programme: 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 at identifying 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 is based on the close interaction between experimental research and theory and the simulation sciences. 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 Programme: Molecular and Cellular Interactions at Functional Interfaces

The aim of biologists, chemists, physicists, IT specialists, engineers and mathematicians working together in the BioInterfaces programme, is to control living systems. Their primary focus is therefore on the smallest “living” units of a biological system - the cells, the cellular components, as well as the interfaces between cells, between cells and their environment, and between molecules, such as proteins in signal cascades. These interfaces are logical switch points that influence cell behaviour. Another focus of the programme is the control of bacteria forming biofilms on surfaces. The programme ranges from pure basic research right up to the development of application-oriented technologies and products, suitable for industry and medicine. New therapies for degenerative dysfunction of the muscles, the retina or the central nervous system as well as the development of bioactive surfaces for implants and bioreactors are enabled by these key technologies.

Technology, Innovation and Society Programme

The goal of this interdisciplinary programme across research fields is the investigation of ecological, economic, political, ethical and social aspects associated with new technologies in order to support 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.

Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research

LIGHT, LIGHTER, MATERIALS RESEARCH

The equation is simple: If one can make a vehicle lighter by 200 kilograms, it consumes one litre less petrol over 100 kilometres and thus emits also less carbon dioxide. In the battle against surplus kilos, the designers of cars and aeroplanes therefore focus on lighter materials, for example, magnesium. That way, the weight of individual parts can be reduced by 30 to 70 percent. According to Professor Dr. Karl Ulrich Kainer, 100 kilogram could be substituted by magnesium in a car. Furthermore, alloys from this metal are considerably stiffer than competing materials with the same mass. “Yet the deformation of magnesium still causes major problems”, says Kainer, who heads the Magnesium Innovations Centre (MagIC) at the Helmholtz-Zentrum Geesthacht.

This is where Helmholtz researchers develop new, more flexible magnesium alloys. They also optimise production processes towards requiring less energy and improving the material properties at the same time. „The CO_2 balance of production processes likewise is included in a vehicle’s total balance“, emphasises Kainer.

NEW PRODUCTION PROCESS FOR MAGNESIUM PARTS:
At the storage ring PETRA III at the DESY, microstructures of alloys can be investigated during deformation in the twin roll casting process.

So far, magnesium parts are being produced predominantly by casting processes. This requires high temperatures and the variety of shapes is limited. HZG researchers work on alternatives using so-called wrought processes such as extrusion, forging and rolling. As of autumn 2010, they will have a new twin roll caster of industrial scale at their disposal. “It is suitable for basic research but allows us also to translate the production process into industrial scales at a faster rate”, says Kainer.

In the twin roll casting process, the liquid material is poured directly between the rolls, where it is rolled out thinly immediately and solidifies. Compared to rolling a block of magnesium, only a few rolling passes are necessary to obtain a sheet of metal for further processing. This saves on energy and costs, for the material does not have to be warmed up again each time. “Furthermore, the quick cooling has a positive effect on the material’s inner structure”, explains Kainer.

The large facility is augmented by another one in miniature format, which even can be transported. This offers the unique chance to examine all steps of the twin roll casting process in detail at the GKSS outstation at DESY in Hamburg. “At the Storage Ring Petra III, we can use highly brilliant x-rays to observe the microstructure from solidification to deformation”, says Professor Dr. Andreas Schreyer, who heads the division

SO FAR, NEW MAGNESIUM ALLOYS STILL ARE PRODUCED IN MAGNESIUM BREEZE OVENS. Photo: HZG

Materials Physics at the HZG. This supplies the researchers not only with valuable information for optimising the process, but helps them also to optimally tailor the material to the new production process.
Primarily, the material characteristics are to be the same in all dimensions. Only then, parts with an even wall thickness can be achieved later. The materials scientists achieve this by adding certain alloy elements. This can be achieved, for example, with magnesium alloys containing zinc and manganese, and which are in the process of being patented.
Another material that has a certain significance in light-weight building is titan-aluminium. In contrast to magnesium, it is suitable for application in very high temperatures from 700 to 800 degrees Celsius and at the same time much lighter than comparable steel or nickel-based alloys. This allows applications with extreme stress such as turbine blades in aeroplanes. “20 years ago, HZG researchers pioneered in this field, by now the material flies in a first aeroplane engine”, reports Schreyer. Now, he and his colleagues want to advance also the latest developments in material to market maturity. The most important goals here are to further increase the temperature range and solve the problems the new alloys still have. “In order to do so, we first have to understand the basics very well, for we don’t want to improve the materials and processes by trial and error, but based on knowledge”, emphasises Schreyer.
The titan-aluminium researchers likewise are able to conduct atomic scale materials analyses with the Helmholtz colleagues at the DESY. For translation into industrial manufacture they closely collaborate with industry partners, as do the magnesium researchers. For instance, they recently licensed a patented HZG alloy to Rolls-Royce and now optimise the material for application in aeroplane engines. UTA DEFFKE

STORAGE TANKS FILLED WITH LIGHT-METAL HYDRIDS ARE SAVE AND RELATIVELY COMPACT. Photo: HZG

Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research

NOVEL HYDROGEN STORAGE SOLUTIONS

Since hydrogen is a volatile gas with a low energy density per volume under ambient pressures and temperatures hydrogen storage is a major challenge for the implementation of a hydrogen based future society. Whoever intends to power his laptop or vehicle with hydrogen and fuel cells requires a tank as compact and lightweight as possible. Scientists around Dr. Martin Dornheim and Dr. Philipp Klaus Pranzas at the GKSS Research Centre Geesthacht focus on the chemical storage of hydrogen in compressed metal powders / powder compacts. The principle: Many metals absorb hydrogen. Thereby stable metal-hydrogen bonds are formed. When the temperature is increased, these bonds break again and the stored hydrogen is released. “The advantage of light metal-hydride storage is, that large quantities of hydrogen – more than in high pressure storage vessels – can be stored in rather small volumes”, explains Dornheim. “Furthermore, the hydrogen is chemically bound, hence we can work at low pressures and do not need to liquefy the gas. The method is very safe, since the hydrogen bound in metal hydrides cannot escape spontaneously in case of an accident and a consequential failure of the tank shell.” Nevertheless, charging and discharging of such hydrogen storage tanks ought to be possible in short times and at temperatures attuned to the respective surrounding drive system. This would allow using the exhaust heat from the drive system to supply the required heat for hydrogen release.
To achieve this, the researchers combine various light metal-hydrides, each with high storage capacity. As RHC – Reactive Hydrid-Composite – these have already been filed as patents. The Clou: The different hydrides react with one another and thereby produce part of the required reaction heat themselves. To further improve the materials, Dornheim, Pranzas and colleagues use experiments with brilliant x-ray radiation at DESY in Hamburg and other European synchrotron sources as well as neutron scattering methods and tomography. Until June 2010, they worked at the Geesthacht Neutron Facility (GeNF) and will concentrate their work more at the neutron source FRM II in Garching in the future. In doing so, they gain insight the nanostructure of the materials and are able to look inside the tank and even monitor how the hydrogen spreads into it. UTA DEFFKE

MARTIN DORNHEIM:
“The hydrogen is chemically bound, hence we can work at low pressure and do not need to liquefy the gas.”

Forschungszentrum Jülich

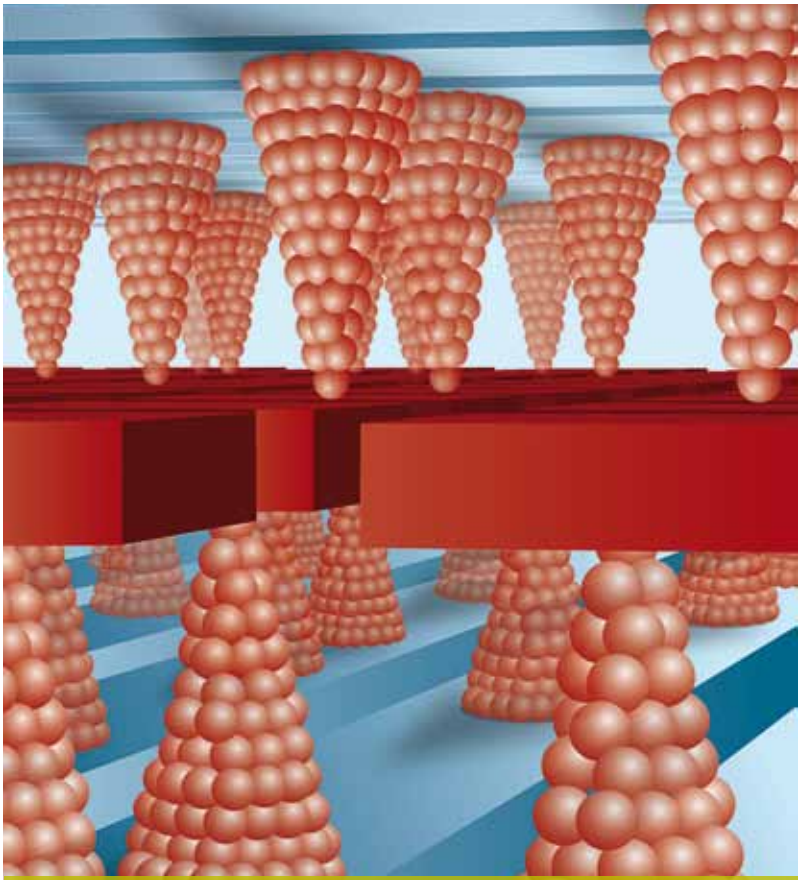
ON THE PATH TOWARDS THE GREEN COMPUTER

World-wide, computers and data centres contribute towards some six percent of electrical energy consumption – with a growing tendency. “Here, we can achieve great economies through the development of entirely new storage concepts”, says Professor Dr. Rainer Waser, Director of the Institute of Solid State Research (IFF) at the Forschungszentrum Jülich. Within the Jülich Aachen Research Alliance JARA, the team around Rainer Waser from the Forschungszentrum Jülich and the RWTH Aachen developed a new concept for the next but one generation of computer chips. It is based on so-called memristive elements, which store information as a high (HRS – High Resistive State) or low (LRS – Low Resistive State) resistance value. A memristor’s resistance can be programmed by applying voltage and then remains valid without further energy input until corresponding counter voltage switches to the other value.

“This is a decisive advantage compared to contemporary computers”, says Waser. “For in current parts for the main memory, DRAMs, the data is stored in form of charge on capacitors. This is volatile and requires permanent renewal.” Also, conventional computer architecture consists of main memory and processor, which are in different locations. The data transport between functional areas thus required leads to a high consumption of energy.

Not only can memristive elements store data, they can also replace capacitors as logic elements for the processor. “In principle, it is possible to conduct arithmetic operations with these elements and to store the results directly in these same or neighbouring elements”, explains Eike Linn, PhD student in Waser’s Research Group. As a result, the energy-intensive data transport between memory and processor becomes obsolete.

Memristors are constructed like a sandwich, for instance, out of a platinum and a copper layer. Between these is an electrolyte, which is permeable for charged particles. When a positive voltage is applied to the copper layer, copper ions form there. They wander through the electrolyte intermediary layer and are reduced to metallic copper on touching the platinum. This results in metallic copper growing towards the copper electrode in the shape of threads or pointy cones. The cell’s resistance is considerably reduced by this conducting bridge. Once a corresponding negative voltage is applied, the entire process is reversed and the copper ions wander back to their layer of origin. Without voltage, the respective condition remains stable.



THE MODEL OF A CRS STRUCTURE IN NANOMETRE RESOLUTION SHOWS ELECTROCHEMICALLY FORMED COPPER ATOM CONES. Photo: Forschungszentrum Jülich/JARA

THE NEXT BUT ONE GENERATION OF COMPUTER CHIPS

Memristive construction elements can both store data and conduct logical operations. This can save a lot of energy.

These storage elements are organised in so-called crossbar arrays. These are grids of crossing conducting paths. The memory cell is located at the cross-sections between upper and lower conducting path. By way of this grid structure, single cells can be addressed in a targeted manner. “However, this does not yet work perfectly in practice”, says Linn. When a cell is switched, the applied voltage can affect also neighbouring cells, in particular, when these are in LRS mode and thus feature a low resistance value. For electricity always goes for the path of least resistance. So far, each cell had a preceding transistor to prevent this happening. Yet this makes chip production more expensive and considerably limits the potential cell, and hence, memory density.

Now, the Jülich and Aachen researchers have developed a new concept. The Clou: They simply connect two memristors

with opposing polarisation at their respective copper layer to form one cell. This results in a switch sequence of one HRS element and one LRS element between conducting paths. That way, a large degree of total resistance is constantly achieved, which is sufficient to prevent leakage currents. These new elements are called complementary resistive switches – CRS.
The two memory states 0 and 1 result from the combination of HRS/LRS or LRS/HRS. By applying a write voltage, they can be switched between 0 and 1. A lower voltage is used for reading and it is registered whether there is a current or not. In the 0 combination HRS/LRS, there is no significant current, since the total resistance is comparatively great. Reading voltage is polarised in such a way, that in this case the HRS and LRS values do not change. Conversely, in the 1 combination LRS/HRS, the HRS value is converted into a LRS value. Then, the element features a low total resistance and current flows. At the same time, the initial value is lost. Reading thus is destructive, the previous condition has to be restored by a corresponding write pulse.
Whereas the concept and switch design was developed by Eike Linn at the RWTH Aachen, his colleagues at the Forschungszentrum Jülich demonstrated the technological feasibility. The new CRS structures can be produced with conventional silicon technology or by way of innovative nanoscale printing methods. As they can be minimised to the scale of below 10 nanometres and can also be stacked high as well as manage without a transistor, the memory density can be increased by the factor ten to one hundred compared to current main memories. “Not only does this save a lot of energy, but it could also delay the end of traditional silicon electronics for a while”, says Waser. And thanks to non-volatile memory, the nuisance of booting the computer could become obsolete at last.

UTA DEFFKE

Forschungszentrum Jülich

NEW DETECTOR FOR DANGEROUS FLUIDS

Jülich physicists have developed a prototype detector, which can reliably and rapidly differentiate between liquid explosives and harmless substances. “Explosive liquids or fluid components from which explosives could be mixed aboard an aircraft, can be identified within split seconds by our method. Our process of controlling fluids is not only faster than others, it is also much more reliable. After all, carrying fluids in one’s hand luggage can be allowed again only, if dangerous substances are safely detected without long queues forming due to long detection times and false alarms”, explains Professor Dr. Knut Urban, Director at the Forschungszentrum Jülich.

Urban and his collaborators at the Institute of Solid State Research (IFF) use a special form of spectroscopy for their detector, which can analyse substances by way of electromagnetic radiation. Every fluid absorbs and reflects radiation of different wavelengths in a different manner and thus can be identified on the basis of its specific “finger print”. In doing so, the finger print is measured across a broad frequency spectrum from just a few gigahertz to some terahertz, which allows for a reliable comparison with reference data from dangerous fluids.

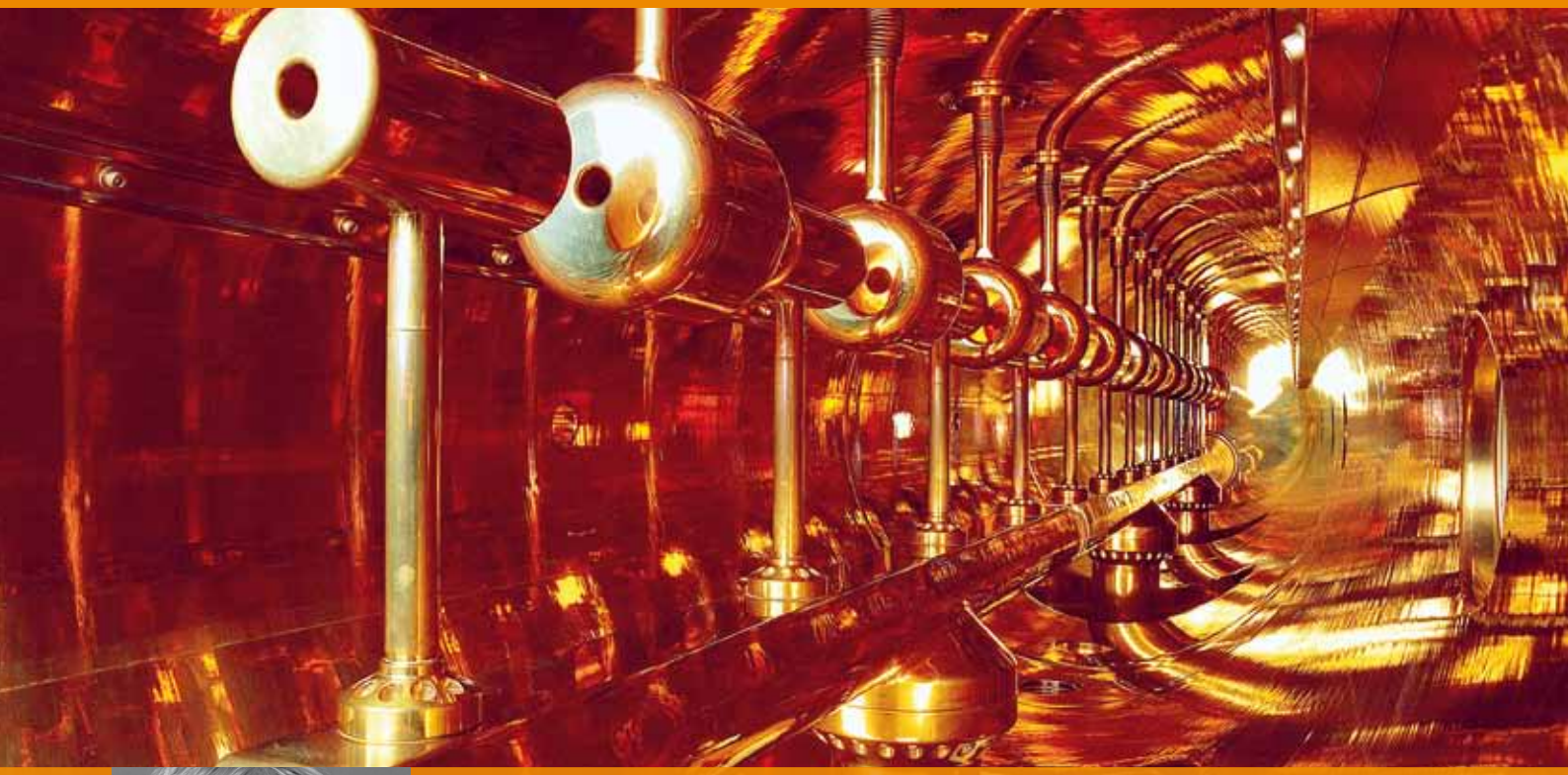
KNUT URBAN:
“With our method, explosive fluids can be identified within split seconds.”

The heart of the so-called Hilbert spectrometer is a nanoelectronic part optimised for the analysis of liquids, a so-called Josephson contact. It functions as a highly sensitive, ultrafast and broadband sensor and, controlled by computer, converts the scanned spectrum into an electric signal. After measuring a time of 0.2 seconds, the detector reliably differentiates between various liquids such as water, ethanol, methanol, propanol and acetone on the one hand and dangerous liquids on the other.

ANGELA WENZIK

THE ASSEMBLY SHOWS THE PROTOTYPE OF THE DETECTOR (CENTRE) AND THE FLUID THAT IS TO BE EXAMINED IN A BOTTLE. THE LIGHT SOURCE IS LOCATED TO THE LEFT OUTSIDE THE PICTURE. Photo: Forschungszentrum Jülich

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, neutron or ion sources – the Helmholtz Association makes available big, sometimes globally unique scientific infrastructures 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 the maximum brilliance of which is ten billion times higher than that of all previously built facilities. Another large-scale research facility with international involvement is being created 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, which will supply ion and antiproton beams of a previously unattained intensity and very high energies. Research in the field Structure of Matter is embedded in national and international roadmaps scheduling the orientation of research activities in the individual programmes to time scales of 10 to 15 years. This basic research simultaneously delivers many different impulses for technological developments.

With its alliances, the Helmholtz Association has created new structures in order to offer the very best research conditions through strong networking. In 2009, the two Helmholtz Alliances "Physics at the Terascale" and "Cosmic Matter in the Laboratory" were successfully continued in the research field Structure of Matter. The network "Physics at the Terascale" bundles German top-level research in the field of elementary particle physics, which is involved in the Large Hadron Collider in CERN (in operation since 2009) and researches there now. For this, the particle physicists from two Helmholtz Centres, the Deutsches Elektronen-Synchrotron DESY and the Karlsruhe Institute of Technology as well as colleagues from a total of 18 universities and the Max Planck Institute for Physics in Munich have joined forces. By this alliance, particle physics in Germany has significantly improved its impact within an increasingly globalised research community, as was asserted by an international review committee in November 2009 during an intermediary review. With the second Alliance "Cosmic Matter in the Laboratory", the new institute "ExtreMe Matter Institute" (EMMI) was founded on the grounds of the GSI, which, by networking with 13 leading research institutions (amongst them also international ones), will form a think tank for research at the FAIR facility. With its scientific results, EMMI with make an important contribution towards the planning of experiments at the new large-scale facilities, which are being built at the GSI, DESY and CERN.
At the turn of the year to 2009, the Helmholtz-Zentrum Berlin für Materialien und Energie (HZB, formerly Hahn Meitner Institute) merged with the Research Centre BESSY to become the largest research institution in Berlin under the name of Helmholtz-Zentrum Berlin für Materialien und Energie.

THE PROGRAMME STRUCTURE
IN THE FUNDING PERIOD 2010-2014

Six Helmholtz Centres work together in the research field Structure of Matter: Deutsches Elektronen-Synchrotron DESY, Forschungszentrum Jülich, Karlsruhe Institute of Technology (KIT), Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research, GSI Helmholtz Centre for Heavy Ion Research and the Helmholtz-Zentrum Berlin für Materialien und Energie. In the first half of 2009, international experts reviewed the strategic focus of the research field and the programmes with excellent results. Since the beginning of the second programme period 2010, the scientists work in four programmes; the programme Condensed Matter was transferred to the research field Key Technologies.

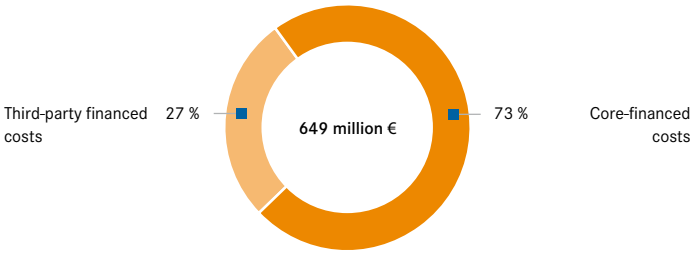
- Elementary Particle Physics
- Astroparticle Physics
- Physics of Hadrons and Nuclei
- Research with Photons, Neutrons and Ions

All programmes build upon 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.

"Synchrotron light and neutron scattering have become indispensible for information as regards molecular structures. Research with this methods requires large-scale facilities such as those at the Helmholtz Association. Such important tools create the knowledge for major scientific progress – for example, in energy research, in the development of catalysts and in yet another research vision: superconductors at room temperature."

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

Total costs of the research field Structure of Matter
Actual costs 2009: 649 million Euro
(incl. the share of non-programme-bound research)



THE PROGRAMMES
IN THE FUNDING PERIOD 2010-2014

Elementary Particle Physics Programme

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 also trace new particles and search for the supersymmetry partners of all presently known particles.
After the shut-down of the large-scale facility HERA at DESY, the programme substantially intensified its involvement in the two LHC experiments ATLAS and CMS. The aim of the programme is the continued safeguarding of Germany's international competitive capability in the field of particle physics. The experimental activities at the LHC are supported by the further expansion of the Grid Computing Centre Karlsruhe (GridKa) at KIT as well as by the Tier2-Centres and the analysis centre at DESY. 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. The DESY plays an internationally leading role in the further development of superconducting accelerator technology. The detector development is likewise being promoted. The theoretical analyses take place in close connection with the experimental activities, yet form also an interface with particle/astroparticle physics and string theory. The lattice gauge theory, including research and development for innovative kinds of processors, will be continued at DESY site in Zeuthen in close collaboration with the John von Neumann Institute of the Forschungszentrum Jülich. The resources for the Helmholtz activities within the very successful alliance "Physics at the Terascale" could be stabilised by the result of the programme review.

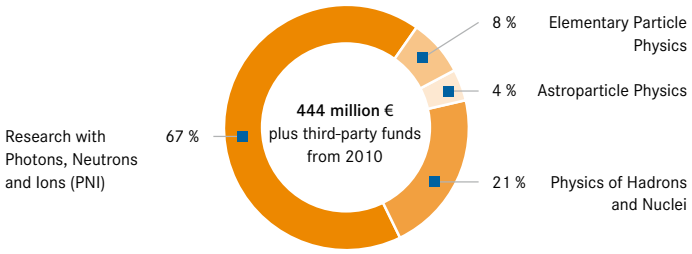
Astroparticle Physics Programme

Astroparticle Physics 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. At the same time, researchers from this programme investigate the so-called dark matter, the presence of which could previously be inferred only from its gravitational effect.
The focus of this programme is the continuation of involvement at the Pierre Auger Observatory and at the ICECUBE Collaboration. The Pierre Auger Collaboration plans to extend the measurements to include the entire sky. In Karlsruhe, accompanying research as regards radio detection of air showers takes place. The neutron telescope ICECUBE will be completed and 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. The search for dark matter is becoming ever more important as a result of new astronomical studies and is to be expanded through the KIT taking a leading role in the European project EURECA. Comprehensively, the so-called Multimessenger Analysis is being advanced, in which information from several celestial sources are to be combined. The KATRIN experiment will conduct its measurements in this programme period and enable the worldwide most sensitive measurement of neutrino mass.

Hadrons and Nuclear Physics Programme

Hadrons – these comprise also the nuclear components protons and neutrons – are made up of quarks that are bound together by their strong interaction. In this programme, the researchers work on fundamental topics such as the quark inclusion in hadrons, the phase transition of quark matter in hadrons, the spontaneous breaking of chiral symmetry of the strong interaction and the connected origin of hadrons and their mass, the characteristics of nuclear multiparticle systems, the exotic nuclei at the border of stability, the creation of superheavy elements and the behaviour of extended nuclear matter in astrophysical objects such as neutron stars and supernovae.

Structure of the research field Structure of Matter
Senate recommendation for core-financing 2010: 444 million Euro
(incl. the share of non-programme-bound research)



On the graphs:

The left graph shows the funds actually employed for the research field Structure of Matter during the report year 2009, divided into core-financed and third-party financed costs.

The right graph depicts the core-financed costs approved by the Senate for the year 2010. In addition, the graph shows the distribution of funds to the programmes from the second round of Programme-oriented Funding. A comparison of current numbers with the depictions from the previous years is possible only to a limited degree, since on the one hand, the Helmholtz Centres have undergone repositioning as regards their research fields and programme structure. On the other hand, the onset of the second round of Programme-oriented Funding brings with it a change from differentiated budgeting between R&D and infrastructure costs to absorption costing.

The focus of the programme for the new programme period is on the leading involvement in the international FAIR project (Facility for Antiproton and Ion Research) at the GSI. This world-wide unique accelerator complex is being jointly built by the GSI and the Forschungszentrum Jülich together with national and international partners and will take up operations as from 2017. In addition to building FAIR, both centres are conducting a targeted experimental programme at the existing facilities (UNILAC/SIS 18 and COSY).
Together with the German universities, the GSI adopts a central part in building and using the ALICE detector within the scope of the heavy ion programme at the LHC at CERN. Furthermore, a powerful Tier2 centre for ALICE is operated at the GSI.
The programme's theory activities with respect to ALICE and the FAIR physics as well as future hadron physics are further strengthened. The topic "Extreme Densities and Temperatures: Cosmic Matter in the Laboratory" is linked with the Helmholtz Alliance EMMI since 2008, with more than 20 international partner institutes involved.

The Research with Photons, Neutrons and Ions (PNI) Programme

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.
With the new topic of "In-house Research", the in-house research on PNI large-scale facilities is strengthened for the first time across centres. This also further improves the prerequisites for qualified user support and the further development of the scientific instruments in the large-scale facilities on an international level.
As regards photon sources, the 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 the European XFEL constitutes an outstanding activity. Likewise, the successful launch of PETRA III as the most brilliant radiation source for hard x-rays worldwide and the further development of the FLASH laser are important successes. After shut-down of the Geesthacht neutron reactor, the HZG is establishing the "Centre for Structure and Dynamics of Condensed Matter on the Nanoscale" as well as the "Engineering Materials Science Centre" at DESY.
As regards BESSY II, efforts are concentrated on the expansion programme "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. ANKA will continue to be further developed as a user facility for special applications in combination with the infrastructure available at the KIT. In collaboration with the research field Health, a Centre for Structural Biology is being created at DESY in order to use the synchrotron sources for the analysis of biological structures.
In the field of research with neutrons, the focus will be on the two national sources BER II and FRM II. In this programme period, the three Helmholtz Centres FZJ, HZG and HZB are engaged in the building and operation of further instruments at the FRM II. As regards the BER II, operated at the HZB with the available extreme probe environments available there, the commissioning of the first expansion stage (25T) of the high-field magnet as well as the upgrade of a selection of instruments and neutron units at BER II and the cold source are on the agenda. On an international level, the Jülich Centre for Neutron Science (JCNS) is engaged at the Spallation Neutron Source (SNS) in Oak Ridge and at the Institut Laue-Langevin (ILL). Furthermore, the three neutron centres are involved in a leading role in the concepts for the European Spallation Neutron Source (ESS) and its instrumentation.
Large-scale facilities for ion research are available at the GSI and offer world-wide unique possibilities for research in the fields of nuclear physics, plasma physics and materials research. The future FAIR project opens up brilliant perspectives for research with ions.
In addition, the programme helped launch an interdisciplinary initiative for data processing and analysis at the PNI large-scale facilities.

PROJECTS

GSI Helmholtz Centre for Heavy Ion Research

A LOOK AT THE COSMIC PRIMEVAL SOUP

Since March 2010, it operates according to routine – the Large Hadron Collider LHC in Geneva, the strongest accelerator of all times. Usually, it uses hydrogen nuclei (protons) to achieve new energy records. Yet as of autumn 2010, the 27 kilometre large ring is to collide the nuclei of lead atoms for the first time. This is when the bell tolls for ALICE: The office building big, 10,000 tons heavy particle detector is specialised on analysing the energy rich collisions of the fast lead nuclei down to the tiniest detail. Physicists from the GSI Helmholtz Centre for Heavy Ion Research in Darmstadt are involved in this to a major degree. They had a leading part in developing two of the altogether 18 subdetectors of ALICE.

By way of the lead experiments at the LHC, the physicists intend to create a state of matter as it must have been shortly after the Big Bang 13.7 billion years ago – the quark gluon plasma. This is the experts' name for a kind of cosmic primeval soup consisting of quarks, the building blocks of protons and neutrons, as well as of gluons, "glue particles" holding together the quarks within the atomic nucleus. Immediately after its birth, the young cosmos must have consisted of this extremely hot primeval soup – if only for a few microseconds. Then it further expanded and got increasingly cold, so that the matter stars and planets are made of could originate.

The LHC can artificially produce quark gluon plasma by colliding lead nuclei at record energy, and thus can reconstruct those conditions of the early universe. Yet this "laboratory primeval soup" is likely to exist only for approximately 10^{-23} seconds. After that, it explodes into thousands of particles flying in all directions. ALICE will measure all these particles in as much detail as possible, so that the physicists can reconstruct the quark gluon plasma – a precise gigantic camera for highly energetic collisions.

ANA MARIN:
"With the LHC, we expect the plasma to exist longer. This enables us to examine the plasma's characteristics for the first time in greater detail."

ALICE is comprised of 18 highly complex subsystems. Two of these, the GSI built in a leading role in cooperation with the universities in Heidelberg, Frankfurt, Darmstadt and Münster. The Time Projection Chamber (TPC) measures the traces of the charged particles produced in a collision. It is of cylindrical shape, some five metres long and thick and filled with a special gas. The particles chasing through the chamber after a collision ionise this gas. This results in the creation of veritable traces of electrons, which are pulled to the cylinder caps by an electric field. There, sensors register the electrons and then a sophisticated software can reconstruct

LEAD NUCLEI ARE TO COLLIDE IN THE PARTICLE DETECTOR ALICE, IN ORDER TO ENABLE CASTING A GLANCE AT THE EARLY UNIVERSE. Photo: CERN

all traces – in 3D. "The TPC is like a big, three-dimensional digital camera with an extremely high number of pixels", explains GSI physicist Dr. Ana Marin. "It is the largest of its kind world-wide."
The Clou: The traces of these polarised particles are bent by a strong magnetic field. "By measuring the bending of the traces, we can deduce the particles' impulse", says Marin. "This is an important value for reconstructing the plasma."
The chamber furthermore ascertains the energy deposition of the particles in the chamber's gas. From this, the researchers can deduce which particle type has caused which trace. A demanding task: The researchers reckon with up to 10,000 charged particles flitting through the detector after a collision.
The second component the GSI experts have considerably contributed to, is the Transition Radiation Detector. It helps the researchers to identify the electrons originating in the collision. It also contributes towards excluding physically uninteresting collisions, which then do not even have to be stored. This considerably relieves ALICE's readout electronics.
The LHC is going to collide the lead nuclei with around 30 times the energy than smaller accelerators such as RHIC in the USA. "In the older experiments the most important thing was to verify by way indication that quark gluon plasma existed at all", explains Ana Marin. "With the LHC, we expect the plasma to last longer and achieve a greater volume. This enables us to examine the plasma's characteristics for the first time in greater detail." No less than 1,500 physicists from all over the world are involved in ALICE. Ultimately, they hope to find new details about the universe's early stages.
ALICE has already performed first measurements with proton collision and the first results are published. "The detector functions superbly", says Ana Marin. "Everything functions as it should." Yet the real excitement starts in autumn. That is when for a whole month lead nuclei are to circle the Geneva ring for the very first time. "And that", says Marin, "then is ALICE's baptism of fire." FRANK GROTELÜSCHEN

Deutsches Elektronen-Synchrotron DESY

NEUTRINO HUNT AT THE SOUTH POLE

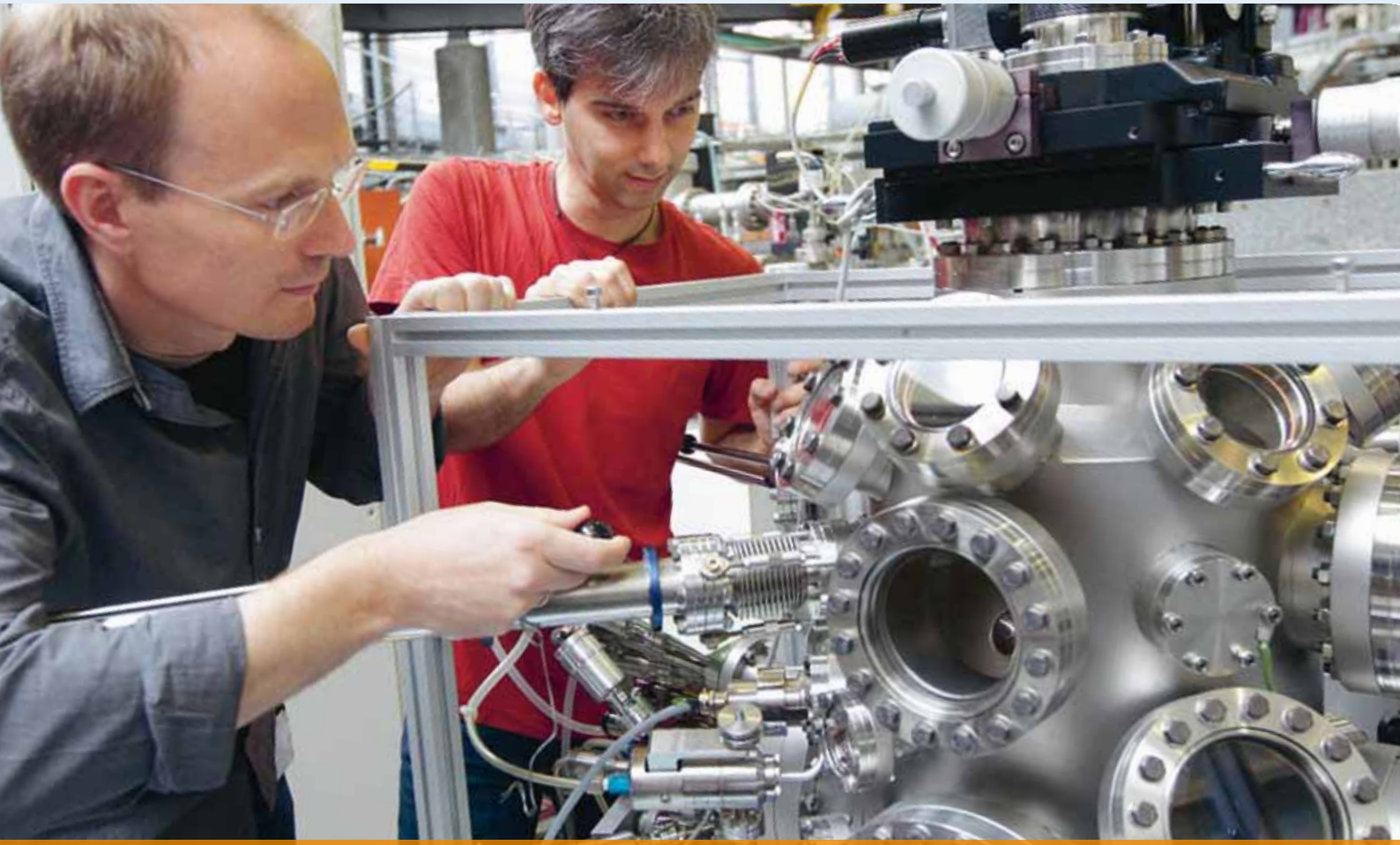
It is the southern-most large-scale experiment of the world: "IceCube" is located at the South Pole and consists of around 5000 optical sensors, held on wire ropes and inserted up to 2.5 kilometres deep into the ice of the Antarctic. The basketball-sized glass spheres register the light signals originating when neutrinos, ghost-like elementary particles, enter into one of their extremely rare reactions with normal matter. IceCube functions as a telescope and is to observe

THE BORE HOLES FOR ICECUBE ARE MOLTEN INTO THE ANTARCTIC ICE WITH HOT WATER. Photo: J. Bolmont

neutrinos from the far corners of space. In January 2011, the large-scale project will be completed after years of building activities. Astroparticle physicists from the DESY in Zeuthen are substantially involved.

CHRISTIAN SPIERING:
"The verification of cosmic neutrinos would give us new insights into cosmic extreme events."

The researchers have to bore altogether 86 holes several kilometres deep with special hot water drillers, in order to insert the wire ropes studded with sensors into the Antarctic ice. 79 holes were completed by the beginning of 2010. The physicists intend to create the remaining seven towards the end of the year, at the beginning of the Antarctic summer. "Yet with the half-finished detector we could already gather a lot of measurement data", says DESY physicist Dr. Christian Spiering.
So far, IceCube has registered more than ten thousand neutrinos. They come from the earth's atmosphere, where they are created by the bombardment with cosmic radiation. In future, IceCube will also target extra-terrestrial neutrinos coming from the far outer space. "Verifying those would generate new insights as regards cosmic extreme events", says Spiering. "We want to find out what happens in the vicinity of black holes, how a supernova explosion unfolds and how cosmic particle accelerators work, which can accelerate nuclear particles to immense energies." FRANK GROTELÜSCHEN



THE HZB RESEARCHERS STUDY THE CHEMICAL STATE OF THE FERROMAGNETIC AND FERROELECTRIC LAYERS BY MEANS OF X-RAY ABSORPTION SPECTROSCOPY. Photo: HZB/M. Setzpfandt

Helmholtz-Zentrum Berlin für Materialien und Energie

DATA AT THE END OF THE TUNNEL

Just like Dr. Manuel Bibes and his colleagues from the French research organisation CNRS south of Paris, Dr. Sergio Valencia and Dr. Florian Kronast from the Helmholtz-Zentrum Berlin (HZB) für Materialien und Energie are classical basic researchers. And yet they show a way towards the development of fast starting computers with low energy consumption with their work on electric control of electron spins. Each electron possesses a so-called spin producing a small magnetic field. "Electric control of the spins could not only revolutionise the main memory in computers but also improve other electronic parts", explains Sergio Valencia.

In today's computers, the main memory in principle consists of electric capacitors, that is, many small memories for electric charges. If the power supply is interrupted, the capacitors discharge and the data is gone. At the next start, the computer pulls the information for the operating system and the installed programmes, which are magnetically permanently stored on the hard drive, back into the main memory. Yet depending on device and programmes, this can take up to some minutes. Only after this "boot process" can the computer be used. In addition, the capacitors in the main memory constantly lose their charge, which has to be refreshed several times per second during normal operation. As a result, the main memory uses a relatively large amount of energy.

SERGIO VALENCIA:
"Electric control of the spins could not only revolutionise the main memory in computers but also improve other electronic parts."

Developers therefore work diligently on systems to magnetically store data. They use the so-called Tunnel Magneto Resistance. "Two thin magnet layers, for example out of iron, are separated from one another by an even thinner isolator", explains Valencia. In principle, this intermediary layer prevents electrons flowing from one magnetic layer to the other. However, if the isolator is only one millionth part of a millimetre thick, quantum mechanical effects allow some electrons to "tunnel" through this barrier layer.

Yet electrons carry not only electric charges, which can be stored in conventional capacitors, but feature also a so-called spin producing a tiny magnetic field. And this mag-

netic field remains even when the power is switched off. When this happens, the spin can have two different directions, called “up” and “down” by physicists. If both of a TMR’s magnetic layers contain mainly spins of the same orientation, the electrons tunnel much more easily than is the case with a magnetic layer, which contains mainly “up” spins, whereas the other contains mainly “down” spins. In principle, with this part one can thus produce a memory, which permanently maintains the binary number “1”, for instance, by way of a tiny section with badly tunnelling electrons and the “0” by good tunnelling. Such a memory based on spins can be rewritten in a manner similarly fast and as often as a conventional electro-capacitor main memory. The read heads of modern hard drives in computers work with such TMR elements, for instance.

Yet in order to write the data, such TMR main memories require relatively strong magnetic fields and therefore also a lot of energy. The CNRS researchers Vincent Garcia and Manuel Bibes therefore created the isolator using a ferro-electric compound called barium titanate. Then, the HZB researchers Sergio Valencia and Florian Kronast examined in detail the chemical composition of the involved magnet layers by using x-ray absorption spectroscopy.

With very little energy, an electric field switches this isolator in such a way, that it carries a slightly positive electric charge on one side and a slightly negative one on the other. If one reverses the electric field, the charge distribution in the barium titanate also reverses. However, each of these two switches influences also the spins in the immediately neighbouring layers and thus obviously also the tunnelling. This organisation has a huge advantage: Data once written there remains even when the power is switched off.

“Following this model, one could, for example, build main memories for computers, which require significantly less energy than current parts, but still store the data permanently and thus boot very quickly when switched on”, hopes Sergio Valencia. With this, the basic researchers from CNRS and HZB opened a door, which could lead towards a fast booting computer that is considerably more environmentally friendly than conventional computers.

ROLAND KNAUER

Helmholtz-Zentrum Berlin für Materialien und Energie

MAGNETIC MONOPOLES IN SPIN ICE

So far, magnetic monopoles have not raised any attention in nature. In contrast to electric charges, magnetic “charges” principally occur only as dipoles with a north and a south pole. Therefore, the discovery of magnetic monopoles in autumn 2009 constituted a sensation. Indeed, Dr. Jonathan Morris, Bastian Klemke and Professor Dr. Alan Tennant from the HZB observed a fascinating phenomenon: At temperatures near absolute zero, they researched the magnetic structures within a dysprosium titanate crystal. This compound is marked by a special geometry as can be found also in frozen water. Whereas in water ice, the hydrogen atoms are located at the corners of tetrahedrons, in “spin ice” dysprosium ions take their place and spatially align their magnetic moments or spins. At around one degree Kelvin above absolute zero,

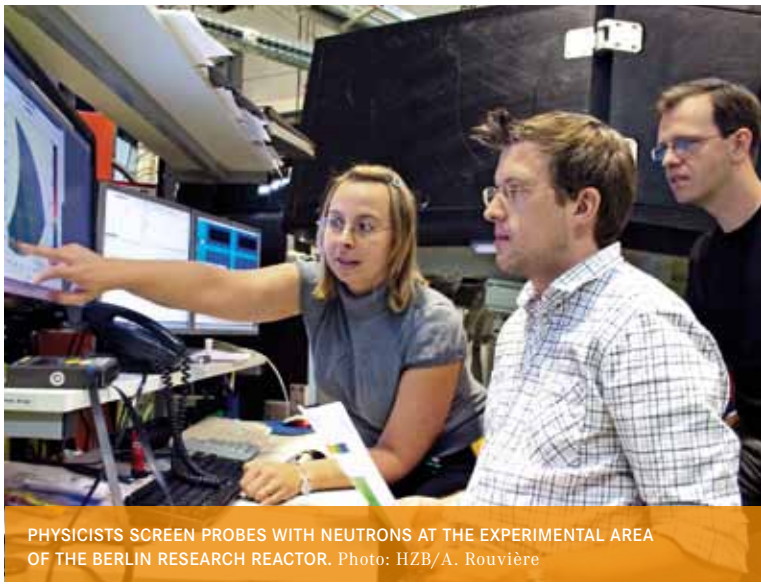
MAGNETIC MONOPOLES

The magnetic monopoles are created by the interplay of an enormous number of atoms within a special geometry and they behave like a new kind of particle.

these spins form long, intertwined chains, so-called spin spaghetti, which the researchers could observe by way of neutron radiation at the Berlin research reactor. They found that the ends of these spin spaghetti behaved like single magnetic monopoles under an external magnetic field. Tennant explains, that an individual chain of magnetic moments was a one-dimensional object in a three-dimensional space. As of a certain length, the ends of these chains can be considered to be free.

Actually, the now verified magnetic monopoles thus are not new particles, because they originate through the interaction of an enormous number of atoms within a special geometry. “Yet they behave like a new kind of particle”, says Tennant. And so they also allow new insights into nature.

ANTONIA RÖTGER



PHYSICISTS SCREEN PROBES WITH NEUTRONS AT THE EXPERIMENTAL AREA OF THE BERLIN RESEARCH REACTOR. Photo: HZB/A. Rouvière

Deutsches Elektronen-Synchrotron DESY

FLASH EXPLORES NEW STATES OF MATTER

Usually, it shimmers in a dull silver – simply typically aluminium. Yet given extreme circumstances, the light metal can become translucent, not for normal light, but for soft x-rays. This feature was discovered by an international team of physicists at the Research Centre DESY in Hamburg by way of the light source FLASH. Amongst other things, the result is of relevance for astrophysics and fusion research.

FLASH is a world-wide unique laser and produces ultra short, highly intensive flashes of soft x-ray light. The 300 metre long facility is based on a superconducting accelerator, which accelerates electrons nearly to the speed of light. The particles fly through "undulators" – structures made out of many hundred pairs of magnets forcing the electrons to take a slalom course. In doing so, the particles emit short, strong laser flashes with wavelengths ranging from extreme ultraviolet to x-ray radiation. Experts call the facility a "Free Electron Laser" (FEL).

The team around DESY physicist Dr. Sven Toleikis managed to bundle the FLASH flashes into a tiny speck of less than a micrometre in diameter by way of a special mirror. As a result, the flash was so concentrated as to produce a remarkable effect when the researchers hit a tiny piece of aluminium with it: The normally non-transparent metal suddenly became transparent in the area of the soft x-ray radiation.

The reason: The energy rich, intensive x-ray light of the FLASH flash kicks electrons out of one of the inner hulls of the aluminium atoms. This causes a drastic change in the metal's absorption behaviour: Suddenly, it lets the x-rays pass, the aluminium becomes transparent. As a result, a most peculiar condition of matter forms: While the atomic rumps of the aluminium continue to form a firm grid, the electrons moving almost freely within the grid possess an extreme amount of energy – considerably more than is usual in a solid body. "It is virtually a combination of crystal and plasma", explains Toleikis. "One can look at it as an initial condition for another exotic form of matter, we call it warm dense matter.

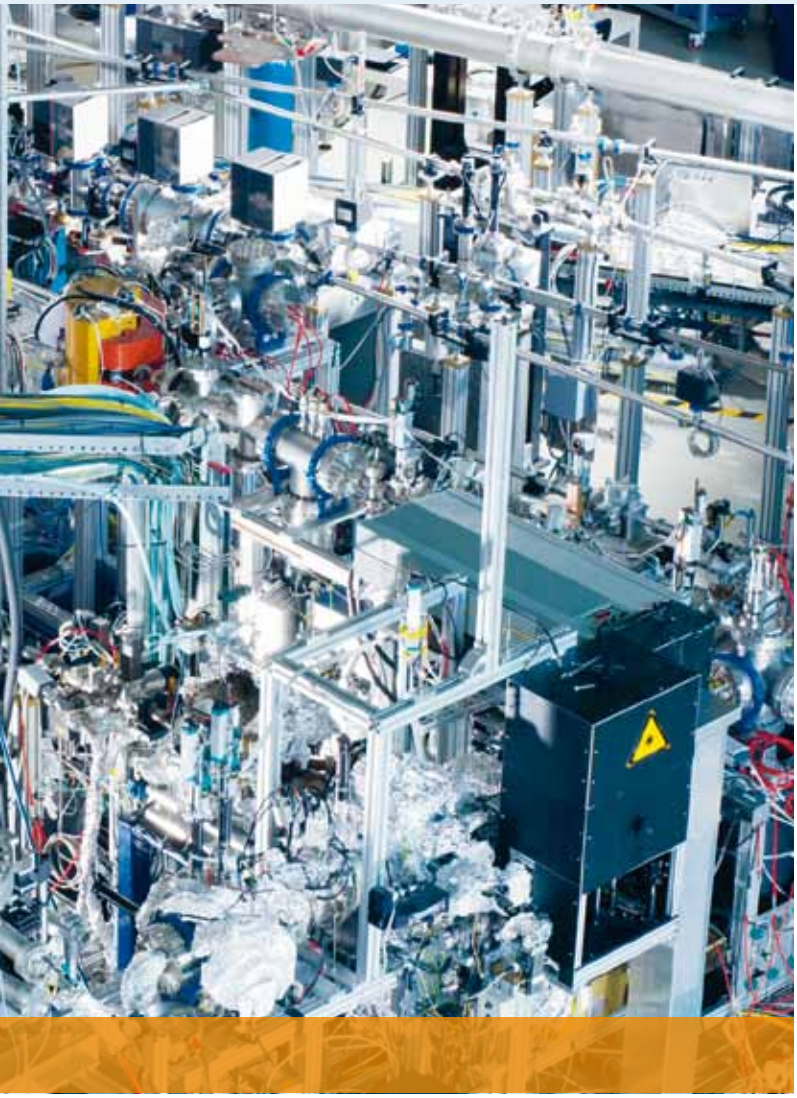
WORK IN PROGRESS IN THE EXPERIMENTAL HALL OF FLASH AT DESY.
Photo: H. Mueller-Elsner/Agentur-Focus.de

SVEN TOLEIKIS:
"It is virtually a combination of crystal and plasma. One can look at it as an initial condition for another exotic form of matter, we call it warm dense matter."

This warm dense matter is of relevance for a very different phenomenon. Experts think that it exists in giant planets such as Jupiter. "By examining this state of matter in more detail in future with facilities like FLASH, one can draw conclusions as to what it might look like inside Jupiter", says Toleikis.

The warm dense matter could also be interesting for the future production of energy, that is, in the artificial nuclear fusion with laser beams. Here, researchers try to shoot at tiny spheres of frozen hydrogen with laser beams in such a manner, that they implode and the hydrogen can melt to form helium. If this succeeds, considerable amounts of energy are releases, which could be converted into electricity in power stations. The warm dense matter is an important transitional state shortly before the actual implosion here. The researchers want to understand it in as much detail as possible, for only then can they optimally activate the hydrogen spheres.

The aluminium experiment is only one of many projects at FLASH. For instance, scientists look at single nanoparticles, research plankton organisms or study highly charged iron ions such as occur in the atmosphere of the sun. Since 2005, FLASH operates routinely. Each year, researchers from all over the world come to experiment at the Hamburg facility. But the laser is totally overbooked: By far not everyone who wants to work with strong x-ray flashes can take their turn. Therefore, DESY now plans a next step called FLASH II in cooperation with the



Helmholtz Zentrum Berlin (HZB). The concept: A second undulator is to be built next to the existing one, fed by the same, already existing linear accelerator. A kind of special point will then distribute the fast electrons to both undulators with lightning speed. The Clou: "The new undulator is adjustable", says DESY physicist Dr. Bart Faatz. "As a result, it can provide different x-ray wavelengths than the existing undulator." Furthermore, the laser characteristics of x-ray and UV flashes are to be much more pronounced than is the case in FLASH. Certain experiments thus can be carried out in a much better manner, for instance, the "filming" of chemical reactions. Behind the second undulator, a new experimental hall is to be built. It allows space for up to six measuring stations – practically doubling the FLASH capacity.

FRANK GROTELÜSCHEN

GSI Helmholtz Centre for Heavy Ion Research

HEAVY ELEMENTS

The hitherto heaviest, officially acknowledged chemical element has the atomic number 112 and was discovered at the GSI Helmholtz Centre for Heavy Ion Research in Darmstadt.

Since February 2010, it at last has a name: Copernicium, chemical symbol "Cn", named for the astronomer Nikolaus Kopernikus. With this, the chemists' union IUPAC accepted the name proposed by the international team of discoverers around the GSI researcher Sigurd Hofmann. In 1996, the team had targeted lead foils with a beam of zinc ions produced in the accelerator UNILAC. For a short moment, the atomic nuclei fused to form a new element – the element 112, which the scientists could identify in a highly sensitive verification process.

ELEMENT 112 BAPTISED, ELEMENT 114 FOUND

In the next few years, the GSI physicists want to create the elements 119 and 120 for the first time.

Copernicium is only an interim stage in the search for new elements. In doing so, the GSI focuses on various strategies. A new measuring apparatus called SHIPTRAP is capable of capturing and storing super heavy ions with a gas cell and a so-called Penning trap. Recently, one succeeded for the first time to capture ions of the elements 102(nobelium) and 103 (Lawrencium) and to measure their mass in detail. The researchers hope the same could be possible with even heavier kinds of atoms.
With another apparatus, the separator TASCA, the GSI experts recently verified another super heavy element, the element 114. The researchers could thereby reproduce a discovery from the Russian Dubna – raising the chances that the IUPAC officially acknowledges the as yet nameless element. "It is the hitherto heaviest kind of atom we have created in Darmstadt", says GSI Department Head Dr. Fritz Peter Hessberger. "In the next few years, we will try to get to the elements 119 and 120." An advance into absolute new territory, for these kinds of atoms still await their discovery.

FRANK GROTELÜSCHEN

THE MASS OF THE ARTIFICIAL ELEMENT 102, NOBELIUM, WAS MEASURED WITH UTMOST PRECISION WITH THE ION TRAP SHIPTRAP. Photo: GSI/G. Otto

RESEARCH FIELD AERONAUTICS, SPACE AND TRANSPORT

PROF. DR.-ING. JOHANN-DIETRICH WÖRNER
Vice-President of the Helmholtz Association,
Coordinator of the Research Field Aeronautics,
Space and Transport, German Aerospace Centre

GOALS AND ROLES

Mobility, information, communication, managing the resources as well as environment and security are decisive factors for the economic, ecological and social development of modern national economics and therefore of highest strategic relevance. Scientists from 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. With their particularly great technological and innovation potential, the activities in the three programmes contribute towards internationally strengthening and rendering visible Germany's role as a location for research and innovation

The German Aerospace Centre (Deutsches Zentrum für Luft- und Raumfahrt, DLR) is the only centre in the Helmholtz research field Aeronautics, Space and Transport. At the same time, it is the Federal Republic of Germany's national research centre for aviation and aerospace and as Germany's national space agency responsible for realising the German government's national space agenda and the contributions towards the European Space Agency ESA.

All 13 DLR sites scattered across the various federal states closely network with universities and non-university research institutions. The DLR also cooperates closely with other Helmholtz Centres, in particular with the two research fields Energy and Earth and Environment.

The instrument DLR@UNI does justice to both the diversity of content and the respective ancillary conditions within the cooperation and establishes a framework for partnerships marked by content. It can consist of various activities from joint research over further education to joint initiatives in business start-ups. By now, three institutional connections have been established on this basis, each tailored especially to meet the demands and each featuring different organisational structures:

- DLR@TU Braunschweig carries the name “Campus Research Airport” and focuses on the theme of aviation and traffic research.
- DLR@Uni Stuttgart has defined a “Research Campus” with the motto “Designing the Future Together”.
- “Munich Aerospace” – a joint faculty of the Technical University Munich, the University of the Federal Armed Forces Munich, the DLR and the Bauhaus Luftfahrt – was established to serve as a research, development and training platform for the Munich aerospace community.

The aim of activities is to use the available resources even more efficiently through direct, institutional cooperation with universities via the already successfully applied practice of joint appointment of institute heads and, in part, department heads.

One outstanding example for industry cooperation is the national earth observation satellite TanDEM-X, which started at the end of June from the spaceport Baikonur in Kazakhstan. The radar satellite TanDEM-X is financed as a public-private partnership project between the DLR and Astrium GmbH with funds from the Federal Ministry of Economics and Technology and is to fly in formation with its twin satellite TerraSAR-X, which already is in orbit, at a distance of in part only 200 metres over the earth to obtain three-dimensional height profiles of land and ocean surfaces.

Another example is the signing of the cooperation agreement with Bombardier Transportation, sealing the pact for long-term collaboration in the field of rail vehicle research. The central goal is to jointly advance research and development of next generation high-speed trains and to optimally use the respective competencies.

The flying Stratosphere Observatory for Infrared Astronomy SOFIA is a joint project of the American space agency NASA and the DLR and was able to observe astronomical infrared objects in flight for the first time in May.

In spring 2010, the measurement flights of the DLR research aircraft FALCON 20E produced valuable insights into the mass currents of ashes and fine dust transported from the volcano Eyjafialla in Iceland as far as to Central Europe. During several measurement flights, the concentration of fine particles, sulphur dioxide, carbon dioxide and ozone could be determined. This data enabled research as to how the particles change their consistency over a longer period of time within the ash, yet could also yield valuable information for decisions regarding flight bans.

THE PROGRAMME STRUCTURE
IN THE FUNDING PERIOD 2009-2013

DLR scientists collaborate in three programmes:

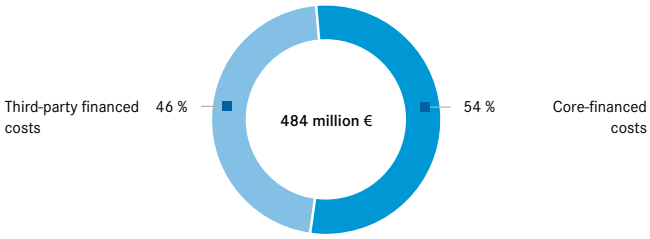
- **Aeronautics**
- **Space**
- **Transport**

The work done in these programmes is characterised by their thematic and organisational integration under the DLR umbrella. Researchers in all three programmes can thus directly draw from jointly required core competencies. Examples for this are aerodynamics, structures and materials, communication, navigation and mechatronics. Synergies arise at the interface of aeronautics, space and transport, for instance, in the area of air and space-supported remote sensing.

“Volcanic ash immobilised the air traffic across Europe and the DLR research aircraft FALCON 20 E helped and still helps to obtain reliable scientific measurements to limit further consequences for Germany and Europe. The Association’s thanks therefore go to all research colleagues for this extraordinary commitment.”

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

Total costs of the research field Aeronautics, Space and Transport
Actual costs 2009: 484 million Euro
(incl. the share of non-programme-bound research)



THE PROGRAMMES
IN THE FUNDING PERIOD 2009-2013

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 Programme

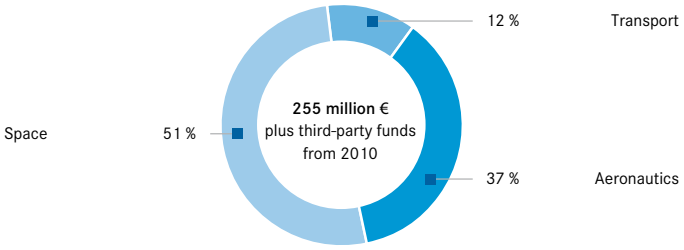
Scientists in DLR aeronautics research work on increasing the performance capability and economy of the air transport system, on reducing flight noise and harmful emissions and on guaranteeing safety. These goals are also targeted within the scope of European collaboration in the EREA Network. For this purpose, the DLR has at its command specially equipped research aircrafts such as FALCON, ATRA and, in future, HALO.
This is why the programme is driving forward its networking with European partners, 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. The work on fixed-wing aircraft has been pooled under the umbrella of DLR/ ONERA Aircraft Research. The helicopter research conducted under the cooperative heading of DLR/ ONERA Rotorcraft Research focuses in particular on expanding the range of application while 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. Here the aim is to equally optimise all components of jet engines. In doing so, new concepts for jet engines are also examined, such as turbofan engines with a very high by-pass ratio and non-sheathed engines. Research on the programme topic “ATM and Flight Operations” concentrates on the field of Air Traffic Management, in particular for the close proximity of airports, but to a special degree also on environmental issues as regards operations. In addition to noise, the aspect of the climate compatibility of air traffic has been moved to the foreground in the last period of time.

Space Programme

Space research in Germany means R&D to provide direct benefits to the public and, simultaneously, inspiration for the future. In the Helmholtz programme Space, scientists observe the system earth, its processes and changes, they explore the solar system, they research scientific connections as regards life and materials under the special conditions of space, yet they also further develop space travel, work on technical solutions for satellite communication and navigation as well as for transporters and landing devices and prepare concrete missions. All this includes collaboration with partners from industry, research institutions, universities, authorities and agencies, as well as public institutions. Hence, the Helmholtz Space Programme is a central link between all the stakeholders and players contributing to space research. In the next couple of years, earth observation will concentrate on research and development for innovative radar, lidar and optical technologies, modern analytical processes and

Structure of the research field Aeronautics, Space and Transport
Senate recommendation for core-financing 2010: 255 million Euro
(incl. the share of non-programme-bound research)



On the graphs:

The left graph shows the funds actually employed for the research field Aeronautics, Space and Transport during the report year 2009, divided into core-financed and third-party financed costs.

The right graph depicts the core-financed costs approved by the Senate for the year 2010. In addition, the graph shows the distribution of funds to the programmes from the second round of Programme-oriented Funding. A comparison of current numbers with the depictions from the previous years is possible only to a limited degree, since on the one hand, the Helmholtz Centres have undergone repositioning as regards their research fields and programme structure. On the other hand, the onset of the second round of Programme-oriented Funding brings with it a change from differentiated budgeting between R&D and infrastructure costs to absorption costing.

the development of high-quality products. In satellite communication, the wider use of optical connections up to the creation of a satellite-based terrabits/s-transport- and distribution network are to be researched and developed. In the field of satellite navigation, the focus is on creating Galileo and developing new applications for it.
In exploring space, the next years will see the execution and preparation of missions to other celestial bodies within the solar system, with a special focus on the search for life and the question regarding habitability of planets. In research under space conditions, the entire range of infrastructures – parabolic flights, sounding rockets and in particular the International Space Station – is being used to broaden the insights into the science of life and materials or, respectively, verify these. To ensure economic space transport, key technologies are researched and technologies for orbital and planetary missions are developed and validated. In space robotics, both technologies for the “On-Orbit-Servicing” are prepared and robotic systems for exploration missions are designed.

Transport Programme

The currently existing traffic system is largely overloaded and faces increasing difficulties absorbing the rising amount of traffic. This chronic overload increasingly jeopardises the competitiveness of the German and European economy. Yet 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. In order to achieve those goals, the DLR develops resolution methods for earth-bound vehicles, traffic management and the traffic system. In doing so, specific traffic expertise is combined with existing competencies from Aeronautics and Space as well as Energy. Central topics in the development of next generation road and rail vehicles are the optimisation of vehicle structures and energy systems, the minimising of driving resistances and wear, the improvement of comfort and, at the same time, the reduction of negative impact on the environment. Individualised assistance systems are core issues, when the aim is to further improve safety and to support traffic participants as regards specific situations. Innovative road, rail and airport management solutions contribute towards 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. With the integral observation of traffic development and environmental effects, new paths in investigating the traffic system are being accessed.

German Aerospace Centre (DLR)

TRAIN OF THE FUTURE

These days, the ICE3 races across Germany on high-speed tracks at 300 kilometres per hour. The energy consumption per passenger equals less than three litres fuel per 100 kilometres. In spite of this high degree of efficiency, rail traffic is caught in a hard competition with aeroplanes and cars. Therefore, nine institutes of the German Aerospace Centre (DLR) have set themselves the goal to halve the energy consumption. Since 2008, they work on the train of the future, the Next Generation Train (NGT) with new concepts for aerodynamics, undercarriages and travelling comfort.

"In the next 15 years, the amount of traffic will continue to increase significantly", says Dr. Joachim Winter, Head of the NGT Project at the DLR Institute of Vehicle Concepts in Stuttgart. Here, rail has the chance not only to maintain its share compared to air and road, but to further expand it. In order to achieve this, the NGT project strives not only to minimise the energy consumption per passenger but also to increase the maximum allowed speed to 400 km/h. At the same time, passengers are to travel comfortably and to be able to work and read in peace, so that it is important to minimise noise and vibration. The basis for all these different goals is a cost-efficient, modular construction mode for the future trains.

SIGFRIED LOOSE:

"In the new tunnel test facility we will be able to investigate real train models at a speed of 360 km/h and side wind. There is no such thing anywhere else world-wide as yet."

The DLR researchers have already presented the first design studies: For instance, the passengers will be seated on two levels in the NGT – similar to the much slower regional trains in use today. The currently used undercarriages with fixed axles could make way for a wheel set equipped with "intelligent" mechanics and electronics. The individual wheels are then to be integrated into the coach body and driven by powerful wheel hub motors.

"Most importantly, we need a consequently new aerodynamic design for the NGR", says Winter. This task primarily challenges the team around Sigfried Loose from the DLR Institute of Aerodynamics and Flow Technology in Göttingen. With one of the most modern wind tunnels of Europe and elaborate air flow simulations, the scientists are coming close to the limits of what is possible. The goal: high dynamic stability and driving safety and minimal noise inside the train at the same time. The new Göttingen tunnel test facility will play and important role here. "As of August, we will be able to investigate real train models at 360 km/h and side wind here. So far, there is nothing like this anywhere in the world", says aerodynamics specialist Loose. Since due to efficiency reasons, the NGT is to be consequently created using light-weight construction, it also becomes more difficult keeping it on track at high speeds. The lifting forces could become so strong in driving fast, that without appropriate measures the train would lose contact with the

THE "NEXT GENERATION TRAIN" IS TO FEATURE TWO STOREYS AND TO REMAIN QUIET AND STABLE EVEN AT HIGH SPEEDS. HERE, A MODEL IMAGE IS DEPICTED. Photo: DLR

DURING THE ALTITUDE RECORD FLIGHT ON 21 NOVEMBER 2009, THE ANTARES DLR-H2 DESIGNERS TESTED THE FUEL CELL SYSTEM FOR THE FIRST TIME UNDER REAL LOW PRESSURE CONDITIONS.
Photo: DLR

ground or, more precisely, with the tracks. “We can improve traction with active, adaptable spoilers, for instance”, clarifies Loose.
In spite of the condensed expert knowledge of the institutes involved in the NGT project, the DLR researchers will not be able to build the train of the future on their own. Yet their expertise as regards aerodynamics and light-weight construction, undercarriages and material wear on the wheels and even energy management is much valued by train manufacturers within the industry. “We currently have a cooperation agreement with Bombardier”, says Loose. But other manufacturers such as Siemens or Alstom can also access the DLR results. Depending on the progress of the current work and commitment on part of industry and railway companies, European high-speed trains could accelerate to 400 km/h during regular service already in the coming decade.

JAN-OLIVER LÖFKEN

German Aerospace Centre (DLR)

ZERO EMISSIONS FLYING LAB

The research aircraft Antares DLR-H2 is the first manned aircraft world-wide powered exclusively by fuel cells. It emits only pure water, rendering take-off, flight and landing CO_2 free and practically silent. The fuel cell drive unit converts hydrogen into electrical energy combustion-free through a direct electrochemical reaction with the oxygen in the air. “The powertrain with a combustion engine in a comparable application achieves only around 28 percent degree of efficiency, whereas the fuel cell achieves 43 percent”, says Head of Project Dr. Josef Kallo from the Institute of Technical Thermodynamics at the DLR site Stuttgart.
The DLR engineers work closely together with project partners from the industry, such as BASF Fuel Cells, Serenergy (Denmark) and Lange Research Aircraft GmbH, where the fuel cell aircraft Antares was built and re-equipped. With 460 kilograms, the basic aircraft Antares is a real light-weight. Two additional external freight containers for the fuel cell system and the hydrogen tank were attached underneath the wings that had to be strengthened for the purpose.
With the Antares DLR-H2, fuel cell systems for powering both the engines of small aeroplanes and the on-board power supply of large aircraft can be tested under real conditions. At the end of 2009, the fuel cell aircraft provided proof that the systems still work at altitudes of above 2,500 metres. “With the altitude record we could verify that the fuel cell flies efficiently and safely even under low pressure”, says Kallo. The fuel cell tests at pressure conditions similar to aviation conditions hitherto conducted at the Stuttgart laboratory hence could be verified during a real flight. “Yet a fuel cell drive unit would be unrealistic for passenger aircraft with their great load. However, their on-board power supply could be provided by a comparable system in future”, explains Kallo. Furthermore, a fuel cell based on-board power supply could also produce water, some 0.5 litres water per hour and per kilowatt output. In the course of a transatlantic flight, between 500 and 3,000 litres water could thus be produced and used, depending on the type of aircraft. As a result, less water has to be carried, so that weight and in turn fuel is reduced.

JOSEF KALLO:
“With the altitude record we could verify that the fuel cell flies efficiently and safely even under low pressure.”

ANTONIA RÖTGER

German Aerospace Centre (DLR)

ELECTROMOBILITY IN GERMANY

A million electric vehicles are to drive on German roads by 2020. The federal government decided on this ambitious goal in its National Development Plan Electromobility. But how will completely electrically powered vehicles and plug-in hybrids with additional combustion motor actually be used? Will electric vehicles change our notion of mobility or are they doomed to suffer a niche existence at best?
Markus Mehlin, Head of the department Passenger Transport at the DLR Institute of Transport Research in Berlin, investigates these questions. In collaboration with E.ON Energie and other partners, his team works on a project on electromobility, in the context of which the Volkswagen AG will bring to the road 30 plug-in hybrids on the basis of the Golf VI model as of autumn 2010. The cars will be driven by people with very diverse demands as regards their personal mobility. With fully loaded batteries, commuters, families with small children or medication delivery services can then drive 50 to 80 kilometres electrically and, if necessary, further distances using diesel or petrol. Detailed driver's logs provide Mehlin and his colleagues with the data for a system analysis revealing the probable potential of usage of the electric vehicles.
"There will be no limitation as regards usage of the vehicles in our project", stresses Mehlin. This differentiates the project also from already launched fleet tests with electric vehicles. For instance, the test drivers will not have to make allowances as regards load or distance travelled compared to conventional vehicles with combustion engines. The DLR researchers focus in particular on inner city and suburban traffic to the city fringes, that is, distances for which the limited range of electric engines is sufficient. According to the study "Mobility in Germany 2002", around 85 percent of distances covered in German everyday usage do not exceed 70 kilometres. "With our study we will be able to demonstrate for which user groups electric vehicles can be suitable and for which they are not", says Mehlin.

MARKUS MEHLIN:
"With our study we will be able to demonstrate for which user groups electric vehicles can be suitable and for which they are not."

Not only driving behaviour and downtimes will enter into the DLR analysis of the fleet test. Mehlin expects to obtain new insights also as regards the economy of electric drive units. One aspect is the higher acquisition price of an electric vehicle compared to the same vehicle with conventional drive unit. Yet this is counterbalanced by lower operating costs. With efficiency degrees of up to 80 percent, the electric engines on the gear hubs can convert energy into movement very efficiently. The batteries can be charged over night at the socket in the garage at home at a very competitive low cost. According to Mehlin, the surplus cost for a hybrid vehicle could quickly be compensated for by the lower costs for driving energy depending on contingent conditions.
Lower operating costs, less emissions and noise in inner cities: these would be the essential advantages. And if the electricity for electric vehicles is produced not by fossil fuel power stations but comes from renewable sources of energy, the CO_2 balance would also be positive. Yet in spite of these advantages, Mehlin does not intend to neglect critical arguments regarding electromobility. "More electric vehicles do not solve a single parking or traffic jam problem", says the DLR traffic researcher. The cheap "fuelling up" at the power

UNTIL 2020, ONE MILLION ELECTRIC VEHICLES ARE TO DRIVE ON GERMAN ROADS. A FLEET TEST AT THE DLR NOW IS TO PROVIDE INFORMATION FOR REALISTIC PROGNOSES ON THE BEHAVIOUR OF DIFFERENT USERS.
Photo: iStockphoto

DLR EXPERTS OPTIMISE THE COMBUSTION PROCESS AT A SHOCK TUBE FACILITY. Photo: DLR

socket could even lead to more traffic. For electric drive units make driving more attractive compared to other means of transport. Therefore, Mehlin cannot rule out the possibility that the fleet test could even result in negative effects regarding public transport or the bicycle, since electric vehicles with their currently short range enter into direct competition with these.

Even though the fleet test supported by the DLR cannot substitute a comprehensive and representative traffic analysis, it will provide important clues as regards the future of electromobility on German roads. It can be expected that all too optimistic prognoses will be augmented by a more realistic analysis of usage. “At least in the medium term, I see the purely electric vehicle as a niche vehicle only, but with the hybrid variants the count of one million could be reached by 2020”, prognosticates Mehlin. JAN-OLIVER LÖFKEN

German Aerospace Centre (DLR)

BIOFUEL FOR AIRCRAFTS

Researchers at the DLR Institute of Combustion Technology in Stuttgart are developing new fuels for the aviation industry. By 2030, for instance, oil-based kerosene could be replaced by fuels produced entirely from biomass. At the same time, the liquids are to be so tailored to combustion in aircraft engines, that they reliably supply more performance at lower levels of emissions and soot.

On the path towards the optimal, as climate neutral as possible designer kerosene, the team of approximately 20 researchers around Institute Director Professor Dr. Manfred Aigner uses test stands such as a high pressure burner or a so-called shock tube. The experiments are accompanied by computer models to coherently simulate the entire reaction sequence during a combustion process. “We can influence up to 50 different parameters such as, for example, ignitability, in order to obtain a fuel that is better than the kerosene licensed these days”, says Aigner.

MANFRED AIGNER:
“We can influence up to 50 different parameters in order to obtain a fuel that is better than the kerosene licensed these days.”

The basis for synthetic fuels is the “Fischer-Tropsch synthesis” invented already in the 1920s in Germany. With this method, natural gas (GtL: gas to liquid) initially can be converted into synthesis gas by adding oxygen and water vapour and in a next step into liquid carbon hydrides. Instead of natural gas, one can also use coal (CtL: coal to liquid) or biomass (BtL: biomass to liquid) as a substitute for oil.

The work of the Stuttgart researchers is followed internationally with great interest. Currently, they are working on a plan for alternative fuels together with partners in the EU project ALFA-BIRD. In addition, there are numerous cooperations with, amongst others, Shell, Rolls-Royce and the technology centre Qatar Science & Technology Park.

JAN-OLIVER LÖFKEN

ERWIN SCHRÖDINGER PRIZE 2010

Particularly in Southeast Asia, millions of people suffer from chronic arsenic poisoning, since the potable water is partially polluted with arsenic. So far, elaborate chemical analyses were necessary to reliably determine the level of arsenic contamination but now there is a new biological test procedure, the application of which requires no special expert knowledge and which is cheap and reliable at the same time. This new test procedure was developed by Professor Dr. Hauke Harms und Dr. Mona C. Wells from the Helmholtz Centre for Environmental Research – UFZ and Professor Dr. Jan-Roelof van der Meer from the University of Lausanne. For this achievement, the scientists are awarded the Erwin Schrödinger Prize 2010, endowed with 50,000 Euro.

Bacteria Sound Arsenic Pollution Alarm

Arsenic is highly toxic and in some regions of the earth finds its way into potable water via geological conditions or mining activities. Slow poisoning with arsenic is treacherous and becomes apparent only after several years. Chronic poisoning with arsenic leads to severe skin damage and kidney and liver dysfunction and can even cause cancer. Over 100 million people are endangered in Southeast Asia in particular, where due to the fast population growth in recent decades deeper ground water reservoirs had to be tapped. Yet Germany likewise has regions where, for example, mining for ore contaminated the ground water with arsenic.

Especially in Southeast Asia, the arsenic pollution varies so much depending on location, that indeed every single well ought to be tested. So far, this required elaborate laboratory analyses, which have to be conducted by experts. Together with their collaborators, the three awardees developed a new test procedure over the course of the last years and obtained trademark protection under the name ARSOlux®. This test reliably reveals within two hours (incubation period) whether and how much the water is polluted with arsenic. The new method can be professionally used even by laypersons. Supported by the spin-off promotion organisation Helmholtz Enterprise Funds (HEF), the scientists have now further developed the

BIOSENSOR ARSOLUX® Photo: UFZ/A. Künzelmann

patented procedure to market maturity and plan to establish an enterprise, which is to produce and distribute the measuring devices and matching test kits as of 2011.
The basic principle of the test was developed at the University of Lausanne in Switzerland by the research group around Professor van der Meer. The procedure is based on insights from microbiology and uses genetically altered bacteria as so-called bioreporters. For this purpose, "reporter genes" were introduced into these bacteria strains, which cause the cells to glow when coming into contact with arsenic. Researchers around Professor Harms at the Department for Environmental Microbiology of the Helmholtz Centre for Environmental Research systematically continued to develop this principle over the course of the last years. Genetically modified bacteria await their application as arsenic reporters in freeze-dried form in test tubes. The test tubes are filled with a water probe and then inserted into an handy device, which measures the degree of luminescence indicating the amount of arsenic concentration. By way of mathematical methods, Dr. Mona Wells, guest scientist at the UFZ, significantly increased the precision and reliability of this procedure, so that it now works even more accurately than simple chemical analyses.
With around 1.5 dollar per test, the ARSOlux® procedure is not only much cheaper but, according to the experts, also more meaningful than a chemical laboratory analysis. In contrast to a purely chemical analysis, the bioreporter bacteria reveal to which degree organisms would absorb certain chemicals and thus provide information on their biological availability and hence also the health hazard deriving from existing substances.

During the last few years, the scientists tested the procedure in measuring campaigns in Vietnam and Bangladesh and illustrated that the ARSOlux® renders robust results. The devices could initially be used in mobile medical units driving from village to village in Bangladesh. Yet international relief organisations could become customers of the enterprise and test prior to boring wells whether the water would be safe to drink.

On the awardees:

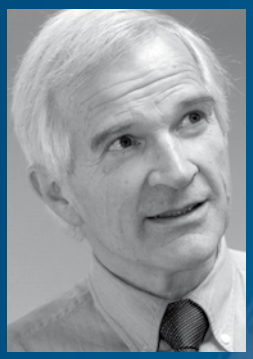
Professor Dr. Hauke Harms works in the interdisciplinary field between biology and physical chemistry and researches in particular the biological availability of chemicals, that is, how chemicals are absorbed by organisms. Hauke Harms heads the Department for Environmental Biology at the Helmholtz Centre for Environmental Research – UFZ.

Professor Dr. Jan-Roelof van der Meer is a microbiologist and researches how bacteria decompose organic environmental chemicals. He also develops genetically modified bacteria strains indicating the existence of certain chemicals. Jan Roelof van der Meer heads a renown major research group at the University of Lausanne.

Chemist Dr. Mona C. Wells is an expert in the field of modelling biological processes and pattern recognition as regards biological reactions to chemical stimuli. She significantly increased the accuracy and reliability of the test procedure by way of statistical methods. A citizen of the USA, Wells works as a guest scientist at the Department of Environmental Microbiology at the Helmholtz Centre for Environmental Research – UFZ since 2008.

With Energy into the Future

THE HELMHOLTZ ASSOCIATION IN FACTS AND FIGURES



PROF. DR. LOUIS SCHLAPBACH, Senator of the Helmholtz Association, Former EMPA, ETH Domain, Switzerland

“We consume one third of energy each for comfort in buildings, mobility and transport as well as for the production of goods. Nuclear technologies contribute only seven percent towards the world-wide production of energy and renewables only a few percent, whereas the rest is based on carbon-rich carbon hydrides with their known CO_2 consequences. The solution for the energy supply of the future will probably be an initial mix of nearly all available technologies with a hopefully rapidly growing share of renewables. Sustainable energy technologies for the days after tomorrow require breakthroughs in interdisciplinary, use inspired basic research as regards energy conversion and storage processes. The Helmholtz Association strengthens the basic energy research right up to the analysis of consequences regarding the climate and environment – a scientific and large-scale technology challenge met by international cooperation and one which also contributes towards increasing the efficiency of energy conversion processes in the future.”

PROF. DR. GERD LITFIN, Senator of the Helmholtz Association, Executive Associate Arkardien Verwaltungs KG

“Designing the energy supply of the future under consideration of ecological and economic aspects is one of the most difficult challenges science faces. With its unique range of research fields, the Helmholtz Association is predestined to decisively contribute towards this task. This applies to its strength in the key technologies in particular for future fields such as electromobility and battery storage.”

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

“By 2050, our Blue Planet Earth will already support some nine billion humans. They all want to overcome poverty, want to live in peace and dignity – they all have a right towards development. Realising this right requires the availability of energy in a special way . Fossil energy sources, which are massively subventioned by the fact that the climate gas CO_2 may be freely emitted into the atmosphere, cannot be the basis for this necessary development. Rather, a revolution of energy efficiency and massive investments for establishing renewable sources of energy at competitive prices are called for. A gigantic, a fascinating challenge for the scientific world.”

PARTNERS IN THE JOINT INITIATIVE FOR RESEARCH AND INNOVATION

Within the context of the Joint Initiative for Research and Innovation, the Helmholtz Association accepted the obligation to develop promising new research fields, to promote young scientists, to campaign for more equal opportunity by way of concrete measures and to further develop cooperations with other research organisations, with universities and in particular with industry partners. These goals constitute the basis of the organisation's strategic planning and activities in the past years.

Since its introduction in 2005, the Joint Initiative for Research and Innovation guaranteed the Helmholtz Association the planning security it needs for its work and allowed it to further develop and establish strategic measures and instruments. According to the resolution of the Joint Science Conference (GWK) of the federal government and the Länder, the annual increase is to be raised from hitherto three to five percent of the total budget of the Helmholtz Association for the second period of the initiative beginning in 2011 scheduled until 2015. The Helmholtz Association expressly welcomes the continuation of this important instrument beyond 2011 and will accordingly take measures towards providing an important contribution towards the further development of the German research community also for the duration of the second period of the Joint Initiative.

Assuring excellence through competition

The procedure of Programme-oriented Funding ensures quality-based distribution of existing research funds within the Helmholtz Association. Here, the research programmes of the Helmholtz Centres are evaluated every five years by international reviewers according to the criteria of scientific excellence and strategic relevance. In the middle of 2009, the second round of Programme-oriented Funding was successfully completed with the review of the research fields Energy, Key Technologies and Structure of Matter. Some 350 international experts were involved in this process and certified the excellent level of research of the Helmholtz Centres.

The Helmholtz Association's outstanding status within the competition with external national and international science institutions is further proven by awards such as scientific prizes awarded to Helmholtz researchers or the raising of funds from the European Research Council. Another example in favour of the international profile of Helmholtz Centres is the European Innovation and Technology (EIT) Institute's award for the coordination of a "Knowledge and Innovation Community" with the subject "InnoEnergy" in December 2009.

Furthermore, Helmholtz Centres and their university partners were particularly successful within the context of the Initiative for Excellence. At present, the Helmholtz Association

RAPE IS A HIGHLY EFFICIENT ENERGY PLANT NOW BEING CULTIVATED ON A LARGE-SCALE. Photo: UFZ

is successful with the Karlsruhe Institute of Technology, the future concept of a "Centre for Molecular Biology Heidelberg" by the DKFZ and the University Heidelberg as well as with the Jülich-Aachen Research Alliance JARA carried by the FZJ and RWTH Aachen. In the context of the planned third round of the Initiative for Excellence, these successes are to be followed up on. Ultimately, the Helmholtz Association contributes towards the competitive capability of the research site Germany by building and operating unique research infrastructures at which more than 4,500 international guest scientists perform research each year.

Creating Promising Partnerships for the Future

The networking with university partners and the economy constitutes an important element in the strategy of the Helmholtz Association. This is the only feasible way to exchange knowledge, ensure the application relevance of research and to efficiently use the resources. The Helmholtz Centres initiate and are involved in a multitude of strategic partnerships. Within the context of alliances and projects, they investigate the pressing questions from science, economy and society. Thus with the KIT Regulation becoming effective in October 2009, the merger of the Research Centre Karlsruhe with the Technical University Karlsruhe to form the Karlsruhe Institute of Technology (KIT) took place. In addition, the Helmholtz Association founded three Helmholtz Institutes in Mainz, Jena and Saarbrucken in cooperation with three German universities and with support from the German Federal Ministry of Education and Research (BMBF). An important milestone in the cooperation with universities – the Helmholtz Association's privileged partners – was also the establishment of the German Centre for Neurodegenerative Diseases in Bonn with six sites in April 2009. On the basis of a successful review within the report period, the Helmholtz Alliances likewise were certified a particularly successful cooperation with universities: In the field of health research, the Helmholtz Health Centres sparked new impulses with an initiative towards the formation of national consortiums dedicated to researching chronic common diseases. Amongst these is the German Centre for Diabetes Research founded in June 2009. Further consortiums for translational cancer research, cardio-vascular research and infection research are being prepared.

> The networking with university partners and the economy constitutes an important element in the strategy of the Helmholtz Association.

The Helmholtz Association established significant cooperations also on an international scale. It is involved, in part in a leading role, in international networks and consortiums, for example in the coordination of international infrastructure consortiums such as the European Strategy Forum on Research Infrastructures (ESFRI). The organisation formulated its future goals in an Internationalisation Strategy. With this Strategy, the Helmholtz Association declares its intention of further developing its position within international research and adopting a shaping influence in international research politics. In doing so, the cooperation with emerging and developing countries will be given special consideration.

The transfer and application of research results constitutes a special focus within the Helmholtz Association. The Helmholtz Centres maintain numerous cooperation projects and enter into strategic partnerships with enterprises. Licence agreements and spin-offs also serve to convert research results into innovative products and services. In order to strengthen this process, the Helmholtz Association developed a new technology

METHANE HYDRATE COMBUSTS SIMILARLY EFFICIENTLY AND CLEAN AS DOES NATURAL GAS. GEOSCIENTISTS PRESUME THERE ARE LARGE DEPOSITS, SO THAT RESEARCHING ITS USE MAKES SENSE. Photo: GFZ

transfer strategy together with external experts and funding bodies. Amongst other things, it includes the establishment of a validating fund of up to 7.5 million Euro per year, which is to create an incentive to further develop inventions towards a commercial product or service proposition.
The past year again saw the successful transfer of research results into applications at the Helmholtz Centres. For instance, scientists from the Forschungszentrum Jülich developed and patented a process for the production of tailor-made pores in materials and optimised it for the material titanium in cooperation with the medical technology company Synthes. The technological know-how can thus be used in the production of disc implants.
After the Heidelberg Ion Beam Therapy Centre (HIT) took up operations, further facilities are now being erected in Marburg and Kiel within the context of a licence agreement between the GSI Helmholtz Centre for Heavy Ion Research with Siemens Medical Solutions. The innovative cancer treatment with ion beams developed at the Darmstadt Helmholtz Centre is a great example for the transfer of insights from basic research into application.
In 2009, the Karlsruhe Institute of Technology signed the founding agreement for the Celitement GmbH together with four inventors and one industry partner. This spin-off will further develop Celitement®, a highly powerful low emission cement, towards its market maturity. Since the innovative building material is produced at low temperatures and with less lime than conventional cement, the Celitement® procedure helps to save some 50 percent of energy and carbon dioxide emissions.

> The Helmholtz Association will continue to fulfil its mission as a strategically acting research organisation in the coming years.

Spin-off founding activities are being promoted within the Helmholtz Association by the Helmholtz Enterprise Fund (HEF). The HEF support of a maximum of 200,000 Euro is financed both by the respective centres and out of the Initiative and Networking Fund. Since 2005, 49 spin-off ideas were funded via this instrument. Further information can be found on p. 88f.

Building on Talent Management and Equal Opportunity

Talent management and measures towards advancing equal opportunity are of special significance within the Helmholtz Association. For this is the only method to win over and keep excellent collaborators. Therefore, the Helmholtz Association invests in the training and further education of its scientific and administrative-technical personnel. The diverse programmes and activities take place both on centre level, for example, by way of practical professional training for young men and women, and on association level, for instance, by way of the management training within the context of the Management Academy. Each year, numerous PhD students complete their doctoral degree at the Helmholtz Graduate Schools and Research Schools of the Helmholtz Centres. In addition, talented post-doctoral students are given the possibility to found their own group of researchers and independently research a scientific topic with funds from the Initiative and Networking Fund.
In order to give women and men equal chances for a professional career within the Helmholtz Association, it established diverse activities for balancing work and family life.

Furthermore, the Helmholtz Association strives towards increasing the number of women in executive positions. Measures such as the mentoring programme for women "Taking the Lead" are to contribute towards this goal. By now, seven women have been assigned positions on the board of the Helmholtz Association, amongst them two as scientific and five as administrative directors. The number of female senators within the Helmholtz Association's Senate is at 26 percent. Ultimately, the Assembly of Members of the Helmholtz Association resolved to follow the "Research-Oriented Standards on Gender Equality" of the Deutsche Forschungsgemeinschaft (DFG, German Research Association) in the further promotion of women.
The Association meets the danger of a lack of new blood in the natural sciences with targeted promotional programmes, the School Labs at Helmholtz Centres, soon to number 26, or with the initiative "Little Scientist's House". More than 50,000 pupils per year currently visit the School Labs. And more than 12,700 kindergartens address some 760,000 children across Germany and raise the enthusiasm of both girls and boys for the natural sciences and technology. Further information can be found on p. 90f.

Responsibly Shaping the Future

The Helmholtz Association will continue to fulfil its mission as a strategically acting research organisation in the coming years. The funds granted also in the future by way of the continuation of the Joint Initiative for Research and Innovation enable the Association to consequently pursue its goals. Even now, it has taken over great responsibility in designing the German science and research system, for instance, by way of building and operating research infrastructures, establishing strategic alliances and innovative partnerships or in the fields of talent management and knowledge and technology transfer. In doing so, the Association has considerably profited from the flexibility measures introduced in the context of the Initiative on Scientific Freedom and has continued to increase its efficiency and effectiveness.
Furthermore, the Association currently works on the further development of the procedure of Programme-oriented Funding with the aim to adapt it to the changing contingent conditions and to safeguard its relevance and efficiency also in the future. The portfolio discussion begun in 2009 – initiated by the Liebenberg Paper and a corner stone paper developed between the Helmholtz Association and funding bodies as a consequence – and a research portfolio and foresight process within the individual research fields are to further strengthen its profile and help to focus its work even more systematically on the pressing questions from science, economy and society. In the context of the foresight process, which is being closely connected to national and international roadmap processes, the Helmholtz Association established dialogue platforms with funding bodies on different levels in order to coordinate long-term strategies as regards future topics. Thus, the research portfolio and foresight process will yield valuable insights in all research fields and further develop the Helmholtz Association's formative role in research fields such as health, climate or energy.
The Helmholtz Association welcomes the continuation of the Joint Initiative for Research and Innovation as an important milestone and indispensable investment into the future of Germany and is fully aware of the ensuing responsibility. The research organisation will fulfil its obligation to energetically conduct research in order to find answers to the pressing questions from science, economy and society and to use the freedom granted responsibly and profitably.

TECHNOLOGY TRANSFER WITHIN THE HELMHOLTZ ASSOCIATION CURRENT BALANCE AND STRATEGIC FURTHER DEVELOPMENT

The Helmholtz Association's mission is not only the pursuit of scientific goals but always also the transfer of insights into applications. Whether by knowledge transfer into society or by technology transfer and entrepreneurial use of economically relevant results – the Helmholtz scientists thus make an important contribution towards Germany's innovation capability. Numerous people work with commitment and success on this at the technology transfer sites of the Helmholtz Centres. These activities are supported by joint models and instruments of the Helmholtz Association. For instance, the utilisation model has been successfully established in the life sciences via the service provider Ascenion GmbH. In the field of Key Technologies, a technology screening project supported by the German Federal Ministry of Education and Research (BMBF) helps to identify utilisation options. Spin-off projects are being supported from out of the Initiative and Networking Fund by the instrument Helmholtz Enterprise and can obtain further management support via the programme HEFplus, which is also financed by the BMBF. These numerous activities contribute towards implementing the Helmholtz Association's mission and yield results – as is illustrated by the Helmholtz Centres' balance in the main transfer channels cooperations, licence agreements and spin-offs.

Cooperations and Strategic Partnerships

In the past year, over 3,100 cooperation projects with enterprises were realised, which resulted in third-party funds of 160 million Euro from the economy. The cooperation forms range from services via joint research projects to strategic partnerships.

- One outstanding example is the strategic partnership between the German Cancer Research Centre and the Bayer Schering Pharma AG. The aim of this long-term collaboration is the faster application of research results in the development of new therapies and medication against cancer. At the core of the cooperation are joint, application-oriented research projects, which can be used as a scientific basis for the development of new substances, therapy or diagnosis procedures and which are being financed in equal share by both partners. So far, nine such projects were selected from numerous funding applications. Joint decision-making committees, mutual visits of scientific delegations, regular meetings of project groups and the joint event of a scientific symposium are evidence of an intensive exchange and an active cooperation culture.

Licences

Another path of transfer and utilisation of technologies is entering into licence agreements for industrial property rights. In 2009 alone, this resulted in income from licences to the amount of around 15 million Euro at the Helmholtz Centres.

- For instance, the Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences and the Herrenknecht AG have entered into licence and cooperation agreements for the production-fit further development of a system for the seismic exploration of tunnels called ISIS. Since the first investigations during the building of the Gotthard basic tunnel, the scientific foundations for ISIS have been developed and the technical components of the system have been optimised for their practical application. In doing so, the Helmholtz Centre pursued a consequent property rights strategy constituting the prerequisite for industrial utilisation. By now, five patent clusters have been licenced to the Herrenknecht AG.

Spin-offs

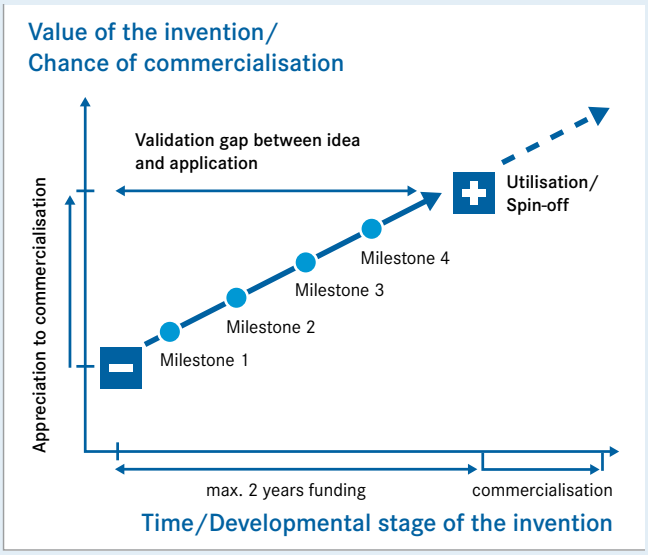
Spin-offs equally constitute a transfer channel leading to the industrial application of research results via new product and service propositions. In the past five years alone, more than 45 spin-offs from out of Helmholtz Centres are recorded, which for the most part were supported by Helmholtz Enterprise. The success of these company start-ups promoted with a maximum of 200,000 Euro becomes apparent not only in the market but is rewarded also by various awards and nominations.

INNOVATIVE MAGNESIUM ALLOYS CAN BE USED IN THE ENERGY-SAVING LIGHT-WEIGHT CONSTRUCTION OF VEHICLE PARTS. Photo: HZG

- For instance, the CSP Services GmbH, founded in 2008 from out of the German Aerospace Centre and offering services in the field of engineering and quality assurance for solar thermal facilities, received the DLR Innovation Award last year for, amongst other things, creating as many as 12 jobs in that short period of time due to the successful development of the enterprise. In 2010, the IONYS AG, a spin-off from out of the Karlsruhe Institute of Technology, was awarded the most important business plan competition of Baden-Württemberg and in addition received the special award of the German Stock Market. This enterprise, established in 2008, further developed and brought to market an innovative construction chemical high-performance material. Thanks to a surface treatment with the hydrophobing gel, buildings can be protected from moisture and corrosion and thus from an expensive complete redevelopment. Nanoscribe GmbH, likewise emerged from out of the Karlsruhe Institute of Technology, has been suggested as a candidate for the German Future Prize 2010 by the German Federal Ministry of Education and Research. It is a great award in itself for the enterprise, which was established in 2008 and produces and distributes laser lithography systems for the production of three-dimensional nanostructures, to be amongst the 20 nominees for the German Federal President's prize for technology and innovation. All three spin-offs were promoted by Helmholtz Enterprise.

Concept for Strengthening the Technology Transfer

In order to enable further technology transfer successes, a new concept for strengthening the technology transfer within the Helmholtz Association was developed in the past year. The strategy's core element is the establishment of a Helmholtz Validation Fund. This is to close the obvious gap between idea and application. An encompassing financial support through the Validation Fund is to enable scientists from Helmholtz Centres to validate research results within two years to the degree of achieving appreciation and commercialisation. Yet the support is not to be of a financial kind only but to consist also of conveying management competencies. For instance, a support model, a continuing education model as well as milestone-based project management are envisioned. The commercialisation of successfully validated projects via industry cooperations, licences or spin-offs will be handled by the centre's technology transfer departments. Income from utilisation will in part flow back into the Validation fund.



Furthermore, the new concept plans for the provision of so-called shared services to further improve the invention and spin-off advisory service. Here, the smaller centres can profit from the existing expertise at the Forschungszentrum Jülich and the Karlsruhe Institute of Technology. Finally, further overarching measures are planned, such as the announcement of a technology transfer prize and further activities for the promotion of a cultural change towards innovation and entrepreneurship within the Helmholtz Association.

TALENT MANAGEMENT WITHIN THE HELMHOLTZ ASSOCIATION

AN INVESTMENT INTO THE FUTURE

The Helmholtz Association understands talent management to be the contributing factor towards increasing Germany's attractiveness as a location for science and perceives the scientific young talents as the key towards successful, internationally competitive research. It therefore sees its responsibility to support and individually promote its highly qualified colleagues in their career.

Yet an encompassing talent management requires also projects for getting children and youths interested in research as well as measures for equal opportunities. With funds from the Initiative and Networking Fund granted by the Joint Initiative for Research and Innovation, the Helmholtz Association realises already numerous activities rendering beyond doubt the role of talent management as a central element of its organisation culture.

Early Promotion of Young Talent

With Helmholtz School Labs totalling 26 very soon and the initiative "Little Scientist´s House", the Association makes its contribution towards the quality of natural science and technological education in Germany as well as towards increasing the number of graduates in these fields. Over 50,000 pupils – many of them in the phase of deciding on a profession – per year visit the School Labs together with their teachers and experience interdisciplinary natural science thought and work by way of independent experiments. The "Little Scientist´s House" initiative addresses an age, at which the enthusiasm of boys and girls for the natural sciences and technology can be kindled the most, that is, the pre-school phase. By now, the project includes more than 12,700 kindergartens and reaches around 760,000 children all across Germany. Local networks ensure that teachers and kindergarten staff across the Republic can profit from professional development and in-service training courses, which have been developed by the initiative.

Pointing Towards Reliable Career Perspectives

Another focus is on the training of talented young scientists or of technical-administrative personnel. By now, some 4,800 PhD students per year are scientifically supported at the Graduate Schools and Research Schools of the Helmholtz Association. They receive interdisciplinary further education beyond their field of promotion and acquire important key competencies for a career in science or the industry. In doing so, collaboration with the universities awarding the doctor titles is further strengthened. Furthermore, more than 1,600 young women and men are educated in technical professions at the Helmholtz Centres.

THE MIRROR TROUGHS OF SOLAR THERMAL POWER STATIONS FOCUS THE SUN'S LIGHT ON A CENTRAL TUBE AND HEAT THE LIQUID CONTAINED THEREIN TO SEVERAL HUNDRED DEGREES. Photo: DLR

With the Helmholtz Young Investigators Groups, the Helmholtz Association supports the early independence of young scientists and offers them a reliable career perspective. This is unique in Germany and renders the Helmholtz Centres attractive for creative talent from all over the world. The programme enables the best young scientists from home and abroad to establish and manage their own research groups. Very good working conditions in a research intensive environment, an early scientific independence as well as the option of a tenure track position are guaranteed here. A particular emphasis is on the close cooperation with universities: The young heads of research collaborate closely with university partners, are given the chance to gather teaching experience and to qualify for a university career.

> The principle of equal opportunity permeates all talent management activities within the Helmholtz Association.

Preparing for Executive Tasks

In order to prepare its executives even better for the demands of research management, the Helmholtz Association launched the Helmholtz Management Academy in spring 2007. Management knowledge tailored to the special demands of the scientific environment is imparted during a structured in-service training. Excellent young scientists and junior executives from the infrastructure and the economic-administrative areas are prepared for future executive tasks. At the same time, the Academy offers also a series of workshops for institute and department heads in order to systematically improve the knowledge management competencies also on this level.

The principle of equal opportunities informs all talent management activities within the Helmholtz Association. Targeted measures are to continually improve the balance between career and family and increase the number of women in executive positions. Amongst these are flexible work time models, child care facilities at the Helmholtz Centres and the establishment of re-entry posts. Thereby, the Helmholtz Association creates, amongst other things, family friendly working conditions for young parents. Furthermore, activities such as the mentoring programme for female young professionals "Taking the Lead" and the Helmholtz Management Academy with some 50 percent of female participants support talented women on their way towards an executive or management position in science or in administration.

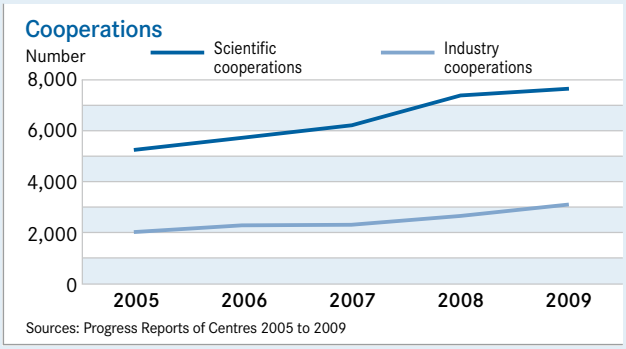
PERFORMANCE RECORD

In the reporting period 2009, the Helmholtz Association has taken important measures to increase the quality, efficiency and performance capability of its research activities. It also launched and implemented numerous new projects and, just as in the past years, shows a solid increase in the relevant performance indicators. The reported figures for the reporting period 2009 are based on the data from the 16 member centres.

In 2009, the 16 Helmholtz Centres received funds for financing costs from the federal government and the *Länder* to the amount of 1,826 million Euro. In addition to these institutionally funded costs, the research centres raised third-party funds to the amount of 1,025 million Euro. Third-party funds from industry cooperations are particularly high in the application-oriented research fields. This can be seen as a clear sign for the attractiveness of the Helmholtz research for industry partners. As regards basic research, funds from support programmes of, for instance, the European Union, the Deutsche Forschungsgemeinschaft (German Research Association) or the federal and state ministries are raised with increased effort via entering into competitions.
Engaging in top-level research and contributing towards solving the grand challenges and pressing questions of our time – this is the mission of the Helmholtz Association. In order to optimally fulfil it, the Association enters into scientific competition. Within the organisation, this takes place in the context of Programme-oriented Funding, the financing of strategic development investments as well as via the instruments supported by the Initiative and Networking Fund. The success indicators reviewed in the context of Programme-oriented Funding can illustrate select aspects of research. Therefore, in the performance record at hand, science-adequate representative success indicators illustrate the most important achievements of the Helmholtz Association.

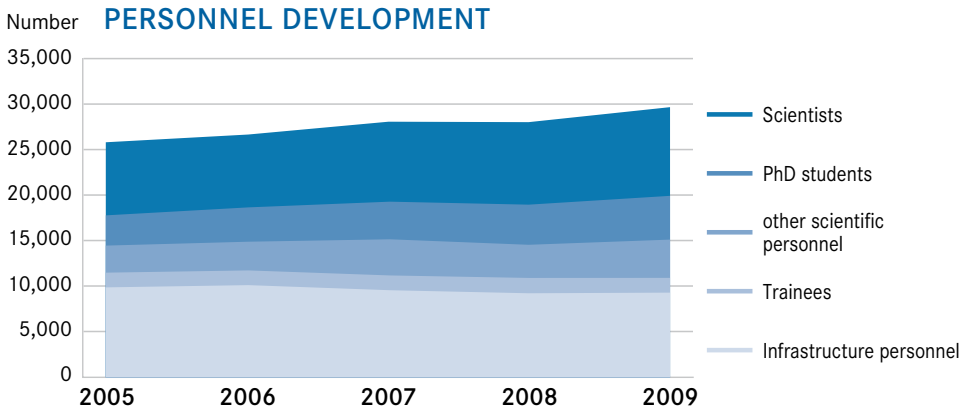
SCIENTIFIC EXCELLENCE

- In 2009, the Helmholtz Centres did research within 7,661 scientific cooperations, constituting an increase by 4 percent compared to the previous year.
- Between 2005 and 2009, the number of cooperations rose by 48 percent (on average 10 percent per year). Here, the number of cooperations with science rose by 46 percent (on average 10 percent per year) and the number of those with industry by 54 percent (on average 12 percent per year).



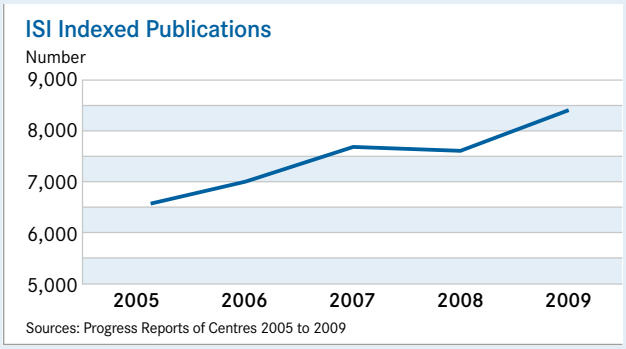
Sources: Progress Reports of Centres 2005 to 2009

- There were 226 involvements in coordinated support programmes of the DFG in 2009. In 2008, participation took place in 218 DFG programmes.
- By 31 December 2009, altogether 262 Helmholtz scientists received calls to W2 or respectively W3 professorships at universities.



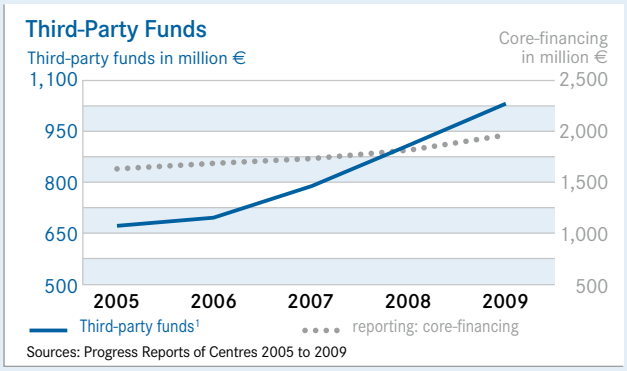
Publications

- In 2009, 8,353 publications were published in ISI indexed scientific journals and a further 2,452 other refereed publications.
- The number of ISI indexed publications increased by 10 per cent compared with the previous year, this is a total increase by 27 percent over the past five years.

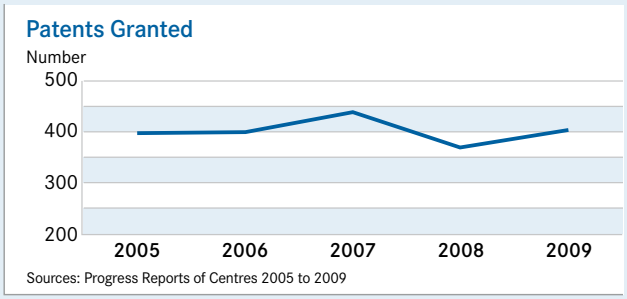


Partner of Industry

- In 2009, much like last year, the EU contributed 131 million Euro. Thus, the Helmholtz Association is leading amongst scientific organisations.
- In 2009, third-party funds to the amount of 1,025 [1] million Euro were raised, constituting an increase of 13 percent compared to the previous year 2008. In 2008, this sum amounted to 909 million Euro.
- This means that the external funds raised in the past five years amounts to a 53 per cent increase, or 11 percent per year on average.



- 405 patents were granted in the report year 2009. This is an increase of 9 percent compared to the previous year. In the preceding years, some 400 patents per year were newly granted.



- Within the past five years, 45 enterprises were founded from within the Helmholtz Association, 6 of these in 2009. This constitutes a fine competitive advantage for the Helmholtz Association.

TOTAL STAFF

Scientific Staff

The Helmholtz Association's total staff amounted to 29,556 employees in 2009 (previous year: 27,913), of these 9,718 were scientists (previous year: 9,043), 4,797 supervised PhD students (previous year: 4,398) and 1,618 trainees (previous year: 1,680). In the scientific, technical and administrative areas worked 13,423 (previous year: 12,792) employees.

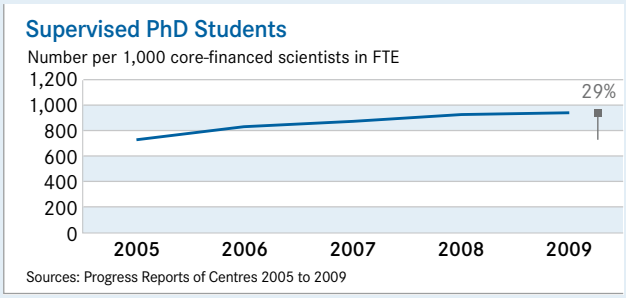
Equal Opportunities

Equivalent to last year, women accounted for a 22.5 percent share of all scientists and researchers and a 37 percent share of the young scientists and researchers. The percentage of women in science management on the level of institute and department head continuously increases. All in all, the proportion of women currently holding scientific, technical and administrative management positions lies at 17 percent, whereas in 2006 it was just 14 percent.

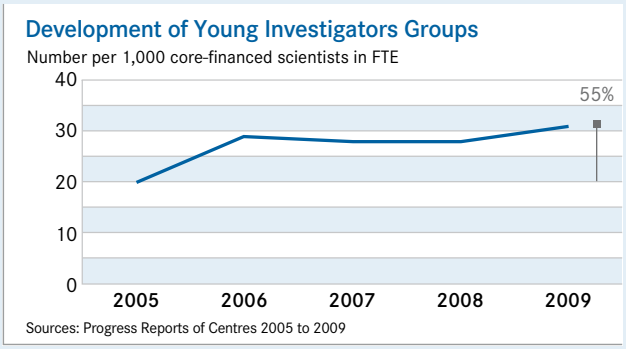
[1] The third-party funds illustrated here include the project funds of 120 million Euro from the German federal government, in particular those for XFEL and FAIR.

Young Scientists and Researchers

- In 2009, the dissertations of 4,797 doctoral students were scientifically supervised at Helmholtz Centres. Compared with 4,398 doctoral students in 2008, this means that 9 percent more doctoral students were scientifically supervised. In the past five years, this number has increased by 45 percent. This equals an average growth of 10 percent per year.
- Standardised to the core-financed scientists, the ratio is roughly one scientist to one PhD student . Here, the share has increased by 29 percent over the past 5 years .



- 1,893 post-doctoral candidates worked at the Helmholtz Association in 2009. This number, too, increased by 11 percent compared to the previous year.
- In 2009, eleven Helmholtz scientists obtained a junior professorship.
- Helmholtz Centres contribute to 48 Graduate Schools of the German Research Foundation (DFG). With this, the level of 2005 is reached again after four years of reduced participation.
- Helmholtz Centres contribute to 67 Marie Curie Funding Measures for the Early Stage Research Training Programme of the European Union. Compared to the two previous years, this constitutes an increase of 56 percent.
- The number of Helmholtz Young Investigators Groups increased from 89 to 159 within five years. This is an increase of altogether 79 percent or an annual average of 17 percent.
- Standardised to the core-financed scientists, the increase in Young Investigators Groups amounts to 55 percent over five years.



- In 2009, 1,618 trainees and apprentices were learning their trade or occupation in the Helmholtz Association. This corresponds to a training quota of 6.5 per cent, related to all staff, excluding doctoral students. In 2008, even 1,680 trainees were taken on. The quota was at 7.1 percent, since the total staff number was lower.
- With by now 25 pupil laboratories and its initiative “Tiny Tots Science Corner”, the Helmholtz Association is contributing towards promoting young researchers long-term with a network of some 12,700 day-care centres and kindergartens.

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 2009 to engage in scientific exchange or to use the research infrastructures. Just over 4,500 scientists and researchers from all around the world used the research opportunities available at the Helmholtz Centres. This is again an increase compared with the previous year.

PROGRAMME-ORIENTED FUNDING

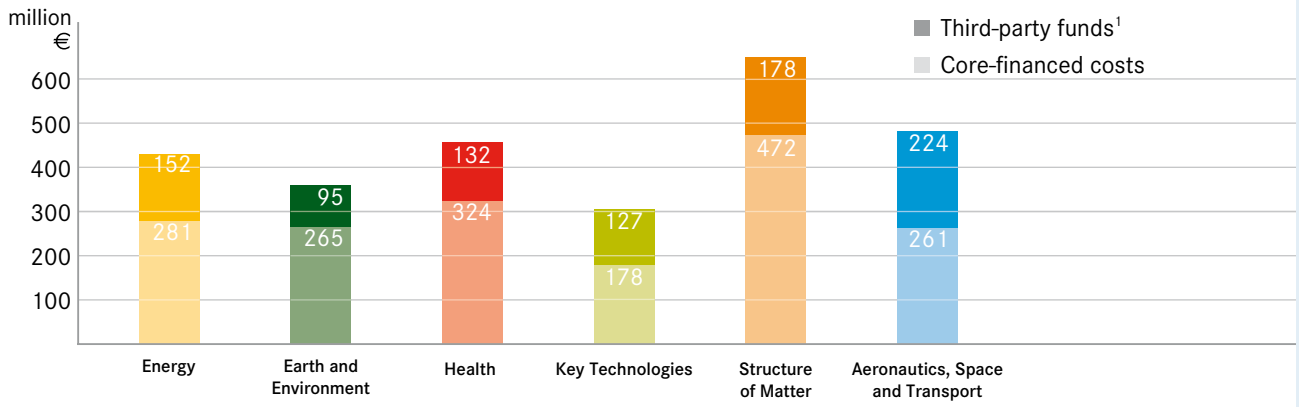
Programme-Oriented Funding

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 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 amount of these sums is linked with the Centres' success in the reviews. It amounts to 20 percent of overall raised programme funds. 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.

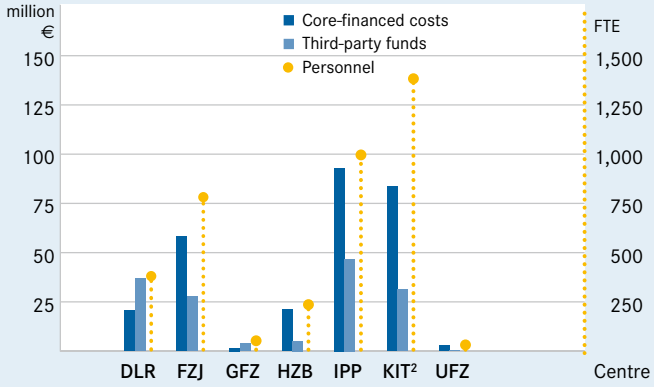
Core- and Third-Party Financed Costs of the Research Fields 2009
(incl. the funds for non-programme-bound research employed for strengthening the existing research programmes)



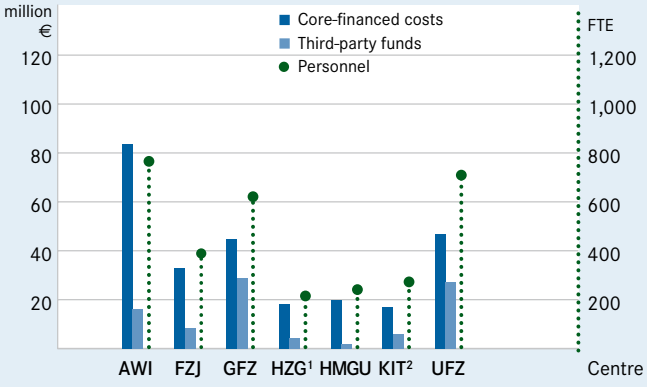
[1)] The third-party funds illustrated here include the project funds of 120 million Euro from the German federal government, in particular those for XFEL and FAIR.

COSTS AND STAFF 2009

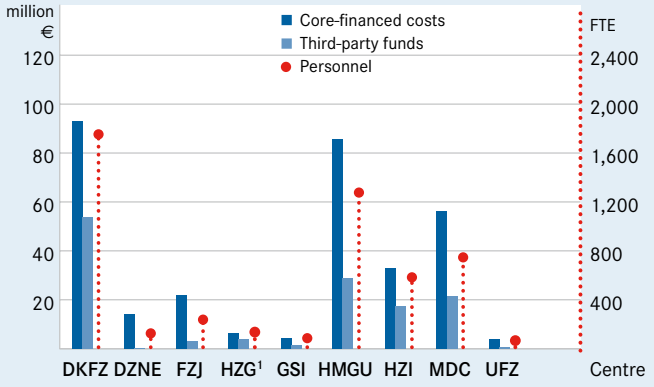
Research Field Energy



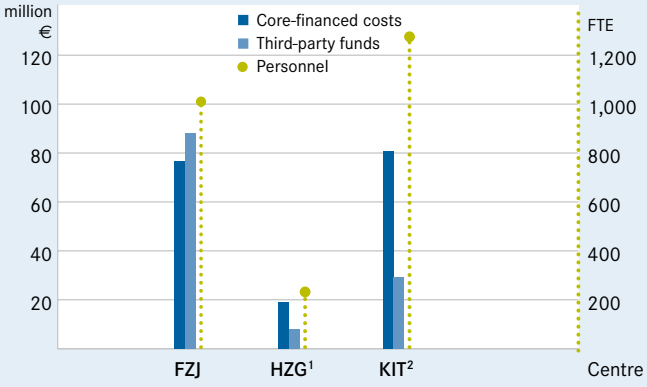
Research Field Earth and Environment



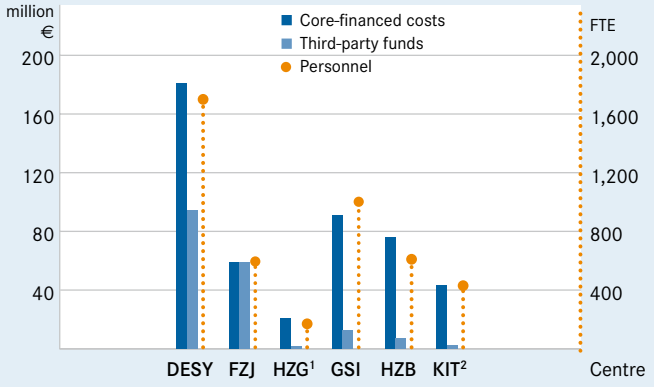
Research Field Health



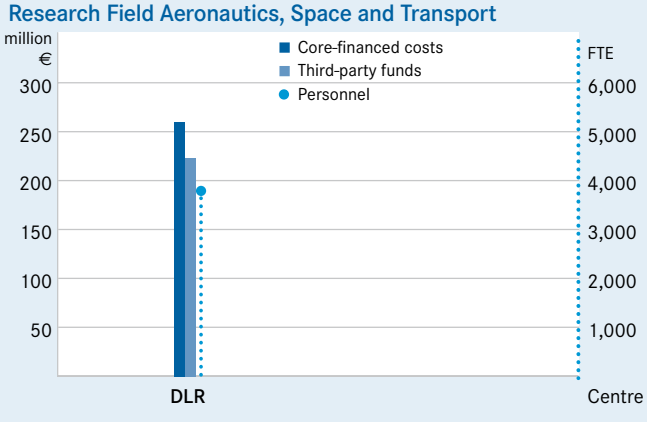
Research Field Key Technologies



Research Field Structure of Matter



Research Field Aeronautics, Space and Transport



[1] By 31 October 2010 GKSS Research Centre Geesthacht [2] Share of large-scale research field at the KIT

OVERVIEW OF Helmholtz Association Costs and Staff

	Costs Core-financed Costs T€	Costs Third -Party Funds T€	Costs Total Costs T€	Costs Total staff FTE
Total, Research Fields	1,780,543	907,009	2,687,552	22,835
Non-programme-bound research[1]	12,043	94,247	106,290	319
Special tasks[2]	33,146	23,953	57,099	1,907
Total, Helmholtz Association	**1,825,732**	**1,025,209**	**2,850,941**	**25,061**[3]

[1] Funding for non-programme-bound research is calculated as up to 20 percent of the total programme funding raised. If centres use these resources to strengthen the existing research programmes, they are allocated directly to the costs of the respective programme.
[2] Prior-ranking dismantling of nuclear facilities [3] In natural persons, this equals 29,556 employees in the Helmholtz Association.

	Core-financed Costs T€	Third-Party Funds T€	Total Costs T€	Total staff FTE
Research Field Energy				
German Aerospace Centre (DLR)	20,608	37,146	57,754	357
Helmholtz Centre for Environmental Research (UFZ)	2,626	67	2,693	25
Helmholtz Centre Potsdam (GFZ)	1,559	3,800	5,359	46
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	21,364	5,113	26,477	230
Karlsruhe Institute of Technology (KIT) [5]	83,618	31,418	115,036	1,380
Max Planck Institute for Plasma Physics (IPP)	93,171	46,863	140,034	992
Forschungszentrum Jülich (FZJ)	58,181	27,791	85,972	777
Total, Research Field Energy	**281,127**	**152,198**	**433,325**	**3,807**
Research Field Earth and Environment				
Alfred Wegener Institute for Polar and Marine Research (AWI)	84,289	16,167	100,456	768
Helmholtz-Zentrum Geesthacht (HZG) [4]	18,336	4,240	22,576	213
Helmholtz Centre for Environmental Research (UFZ)	47,496	27,506	75,002	711
Helmholtz Centre Potsdam (GFZ)	45,417	28,927	74,344	622
Helmholtz Zentrum München (HMGU)	18,840	3,781	22,621	244
Karlsruhe Institute of Technology (KIT) [5]	17,154	5,943	23,097	270
Forschungszentrum Jülich (FZJ)	33,154	8,333	41,487	384
Total, Research Field Earth and Environment	**264,686**	**94,897**	**359,583**	**3,212**
Research Field Health				
German Cancer Research Centre (DKFZ)	94,024	54,320	148,344	1,815
German Centre for Neurodegenerative Diseases (DZNE)	14,358	0	14,358	119
Helmholtz-Zentrum Geesthacht (HZG) [4]	6,213	4,049	10,262	104
GSI Helmholtz Centre for Heavy Ion Research (GSI)	4,315	1,263	5,578	78
Helmholtz Centre for Environmental Research (UFZ)	4,320	789	5,109	46
Helmholtz Centre for Infection Research (HZI)	36,803	17,709	54,512	575
Helmholtz Zentrum München (HMGU)	85,770	28,981	114,751	1,271
Max Delbrück Center for Molecular Medicine (MDC)	56,628	21,875	78,503	793
Forschungszentrum Jülich (FZJ)	21,985	2,981	24,966	236
Total, Research Field Health	**324,416**	**131,967**	**456,383**	**5,037**
Research Field Key Technologies				
Helmholtz-Zentrum Geesthacht (HZG) [4]	19,050	8,250	27,300	229
Karlsruhe Institute of Technology (KIT) [5]	81,675	29,611	111,286	1,283
Forschungszentrum Jülich (FZJ)	77,257	88,983	166,240	1,015
Total, Research Field Key Technologies	**177,982**	**126,844**	**304,826**	**2,527**
Research Field Structure of Matter [6]				
Deutsches Elektronen-Synchrotron (DESY)	180,836	94,675	275,511	1,691
Helmholtz-Zentrum Geesthacht (HZG) [4]	20,592	1,458	22,050	161
GSI Helmholtz Centre for Heavy Ion Research (GSI)	91,165	12,761	103,926	993
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	76,318	7,042	83,360	601
Karlsruhe Institute of Technology (KIT) [5]	43,555	2,361	45,916	421
Forschungszentrum Jülich (FZJ)	59,270	59,281	118,551	586
Total, Research Field Structure of Matter	**471,736**	**177,578**	**649,314**	**4,453**
Research Field Aeronautics, Space and Transport				
German Aerospace Centre (DLR)	260,596	223,525	484,121	3,799
Total, Research Field Aeronautics, Space and Transport	**260,596**	**223,525**	**484,121**	**3,799**

[4] By 31 October 2010 GKSS Research Centre Geesthacht
[5] Share of large-scale research field at the KIT
[6] The third-party funds illustrated here include the project funds of 120 million Euro from the German federal government, in particular those for XFEL and FAIR.

The Helmholtz Association's annual budget is made up of core financing and third-party funding. The core financing is provided by the federal government and the respective states in which the member centres are registered at a ratio of 90 percent federal government to 10 percent federal states. The centres raise some 30 percent of the total budget themselves in the form of third-party funds. In the Annual Report, these core-financed and third-party financed costs are illustrated for the reporting period 2009. Due to the strategic orientation of the Helmholtz Association in six research fields, the total costs are given according to research field (see p. 97). For a clearer overview over 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, as well as at centre level (see below).

Costs and Staff by Centre in 2009	Core-financed Costs T€	Third-Party Funds T€	Total Costs T€	Total staff FTE
Alfred Wegener Institute for Polar and Marine Research (AWI)	84,289	16,167	100,456	768
Deutsches Elektronen-Synchrotron (DESY)	180,836	94,675	275,511	1,691
German Aerospace Centre (DLR)	281,204	260,671	541,875	4,156
German Cancer Research Centre (DKFZ)	94,024	54,320	148,344	1,815
German Centre for Neurodegenerative Diseases (DZNE)	14,358	0	14,358	119
Helmholtz-Zentrum Geesthacht (HZG)[1]	64,191	17,997	82,188	707
GSI Helmholtz Centre for Heavy Ion Research (GSI)	95,480	14,024	109,504	1,071
Helmholtz Centre for Environmental Research – UFZ	54,442	28,362	82,804	782
Helmholtz Centre for Infection Research (HZI)	36,803	17,709	54,512	575
Helmholtz Centre Potsdam (GFZ)	46,976	32,727	79,703	668
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	97,682	12,155	109,837	831
Helmholtz Zentrum München (HMGU)	104,610	32,762	137,372	1,515
Karlsruhe Institute of Technology (KIT)[2]	226,002	69,333	295,335	3,354
Max Delbrück Center for Molecular Medicine (MDC)	56,628	21,875	78,503	793
Max Planck Institute for Plasma Physics (IPP)	93,171	46,863	140,034	992
Forschungszentrum Jülich (FZJ)	249,847	187,369	437,216	2,998
Non-programme-bound Research	**12,043**	**94,247**	**106,290**	**319**
Special tasks	**33,146**	**23,953**	**57,099**	**1,907**
Total, Helmholtz Association	**1,825,732**	**1,025,209**[3]	**2,850,941**	**25,061**[4]

[1] By 31 October 2010 GKSS Research Centre Geesthacht
[2] Share of large-scale research field at the KIT
[3] The third-party funds illustrated here include the project funds of 120 million Euro from the German federal government, in particular those for XFEL and FAIR.
[4] In terms of natural persons, the Helmholtz Association employs 29,556 staff.

THE SECOND PERIOD 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. In 2010, the second period started for the research fields Energy, Key Technologies and Structure of Matter. The centres involved in these research fields reorganised themselves for this purpose and bundled their R&D capacities in these fields in altogether 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.

Funding 2009-2013

Research Field Earth and Environment	Core-financed Costs T€
AWI	448,633
FZJ	148,243
GFZ	198,863
HZG[1]	100,908
HMGU	92,513
KIT[2]	90,732
UFZ	227,084
Sum Total	**1,306,976**
Research Field Health	
DKFZ	599,137
DZNE	186,667[3]
FZJ	151,424
HZG[1]	25,269
GSI	19,333
HMGU	403,750
HZI	220,761
MDC	297,781
UFZ	27,431
Sum Total	**1,931,553**
Research Field Aeronautics, Space and Transport	
DLR	1,317,145
Sum Total	**1,317,145**

Funding 2010–2014

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

During the current period of Programme-oriented Funding, the future Helmholtz Centre Dresden-Rossendorf (HZDR) with a prospective budget of 78 million Euro in 2011 and 74 million Euro in 2012 ff will be included. An allocation to researchs fields will take place in the third round of Programme-oriented Funding.
Graphs illustrating the distribution of funds on programme level are next to the description of the programmes as regards their content on the respective pages of the research fields (Energy p. 19, Earth and Environment p. 33, Health p. 43, Key Technologies p. 57, Structure of Matter p. 65, Aeronautics, Space and Transport p. 75).

[1] By 31 October 2010 GKSS Research Centre Geesthacht
[2] Share of large-scale research field at the KIT [3] On the basis of the DZNE's approved budget for the years 2009 and 2010.

CENTRAL BODIES

PRESIDENT

Prof. Dr. Jürgen Mlynek

VICE-PRESIDENTS

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

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

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

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

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

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

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

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

HEAD OFFICE

Managing Director
Dr. Rolf Zettl

SENATE

ELECTED MEMBERS

Prof. Dr. Dr. Andreas Barner, Spokesman of the Management and Head of the Division Pharmaceutical Research, Development and Medicine, Boehringer Ingelheim GmbH, Ingelheim

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

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

Prof. Dr. Gerd Litfin, Managing Partner of Arkadien Verwaltungs-KG, Göttingen

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

Dr. Detlef Müller-Wiesner, Senior Vice-President, Chief Operating Officer Innovation und 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. Louis Schlapbach, Former EMPA, ETH Domain, Switzerland

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

EX OFFICIO SENATE MEMBERS

Prof. Dr. Peter Frankenberg, Minister for Science, Research and the Arts of the State of Baden-Württemberg, Stuttgart

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

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

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

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

Michael Kretschmer, Member of the German Bundestag, Berlin

Prof. Dr. Karl Ulrich Mayer, President of the Leibniz Association (Gottfried Wilhelm Leibniz Scientific Community), Berlin

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

René Röspel, Member of the German Bundestag, Berlin

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

Dr. Michael Voges, Councillor of State, Department of Finances of the City of Hamburg

EX OFFICIO 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 of the Helmholtz Zentrum München – German Research Center for Environmental Health

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

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 Centre (DLR), Cologne

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

Dr. Martin Lipp, Chairperson of the Committee of Scientific-Technical Councils of the Helmholtz Centres, Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch

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

N.N., Vice-Chairperson of the Scientific-Technical Councils of the Helmholtz Centres

Horst Stöcker, Vice-President of the Helmholtz Association, Scientific Managing Director of the GSI Helmholtz Centre for Heavy Ion Research, Darmstadt

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, Karlsruhe

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

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

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

ASSEMBLY OF MEMBERS

Alfred Wegener Institute for Polar and Marine Research, SdöR (foundation under public law)
Prof. Dr. Karin Lochte, Director,
Dr. Heike Wolke, Administrative Director

Deutsches Elektronen-Synchrotron DESY, SdöR (foundation under public law)
Prof. Dr. Helmut Dosch,
Chairman of the Board of Directors,
Christian Scherf, Administrative Director

German Cancer Research Centre, SdöR (foundation under public law)
Prof. Dr. Otmar D. Wiestler,
Chairman of the Management Board and Scientific Member of the Board,
Dr. Josef Puchta, Administrative-Commercial Member of the Management Board

German Aerospace Centre e.V.
Prof. Dr.-Ing. Johann-Dietrich Wörner,
Chairman of the Executive Board,
Klaus Hamacher, Vice-Chairman of the Executive Board

German Centre for Neurodegenerative Diseases e.V. (DZNE)
Prof. Dr. Dr. Pierluigi Nicotera,
Scientific Member of the Board,
Ursula Weyrich, Administrative Director

Forschungszentrum Jülich GmbH
Prof. Dr. Achim Bachem,
Chairman of the Board of Directors,
Dr. Ulrich Krafft, Vice-Chairman of the Executive Board

Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research GmbH
Prof. Dr. Wolfgang Kaysser,
Scientific-Technical Director,
Michael Ganß,
Administrative Director

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

Helmholtz-Zentrum Berlin für Materialien und Energie GmbH
Prof. Dr.-Ing. Anke Rita Kaysser-Pyzalla,
Scientific Director
Dr. Ulrich Breuer,
Administrative Director

Helmholtz Centre for Infection Research GmbH
Prof. Dr. Jürgen Wehland,
Scientific Director
(deceased on 16 August 2010),
Dr. Ulf Richter,
Administrative Director

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

Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, SdöR (foundation under public law)
Prof. Dr. Reinhard F. Hüttl,
Chairman of the Executive Board and Spokesperson of the Board,
Dr. Bernhard Raiser, Administrative Executive Board

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

Karlsruhe Institute of Technology, KdöR (corporation under public law)
Prof. Dr. Eberhard Umbach, President,
Dr. Alexander Kurz, Vice-President

Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch, SdöR (foundation under public law)
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 Wenninger-Mrozek,
Administrative Director

SCIENTIFIC AWARDS AND PRIZES FOR RESEARCHERS

Prizes as from a value of 10,000 Euro and special select accolades, period 2009/2010

AI **Alfven Prize 2010 of the European Physical Society**
Prof. Dr. Allan Boozer, External Scientific Member, and **Prof. Dr. Jürgen Nührenberg,** Former Scientific Member of the Max Planck Institute for Plasma Physics

Analytica Research Prize 2010 of the Society for Biochemistry and Molecular Biology (GBM) and health company Roche
Dr. Matthias Selbach, Max Delbrück Center for Molecular Medicine (MDC)

APS Compton Award
Dr. Gerhard Grübel, Deutsches Elektronen-Synchrotron DESY

Award for Research Cooperation and Highest Excellence in Science (ARCHES) of the Minerva Foundation
Prof. Dr. Lars Zender, Helmholtz Centre for Infection Research

BI **Bayer Climate Award, Bayer Science & Education Foundation**
Prof. Dr. Peter Lemke, Alfred Wegener Institute for Polar and Marine Research

Felix Burda Award 2010
Prof. Dr. Hermann Brenner, Dr. Ulrike Haug, Dr. Sabrina Hundt, German Cancer Research Centre

CI **Cancer Award – BBAW Prize of the Monika Kutzner Foundation**
Prof. Dr. Lars Zender, Helmholtz Centre for Infection Research

EI **ERC Advanced Grant of the European Research Council (ERC)**
Prof. Dr. Christof Niehrs, German Cancer Research Centre

ERC Starting Grant of the European Research Council (ERC)
Dr. Mathias Heikenwälder, Helmholtz Zentrum München – German Centre for Environmental Health

ERC Starting Grant of the European Research Council (ERC)
Dr. Dr. Melanie Königshoff, Helmholtz Zentrum München – German Centre for Environmental Health

ERC Starting Grant of the European Research Council (ERC)
Dr. Heiko Lickert, Helmholtz Zentrum München – German Centre for Environmental Health

ERC Starting Grant of the European Research Council (ERC)
Dr. Daniel Razansky, Helmholtz Zentrum München – German Centre for Environmental Health

ERC Starting Grant of the European Research Council (ERC)
Dr. Francesca Spagnoli, Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch

ERC Starting Grant of the European Research Council (ERC)
Dr. Aurelio Telemann, German Cancer Research Centre

ERC Starting Grant of the European Research Council (ERC)
Prof. Dr. Dr. Fabian Theis, Helmholtz Zentrum München - German Centre for Environmental Health

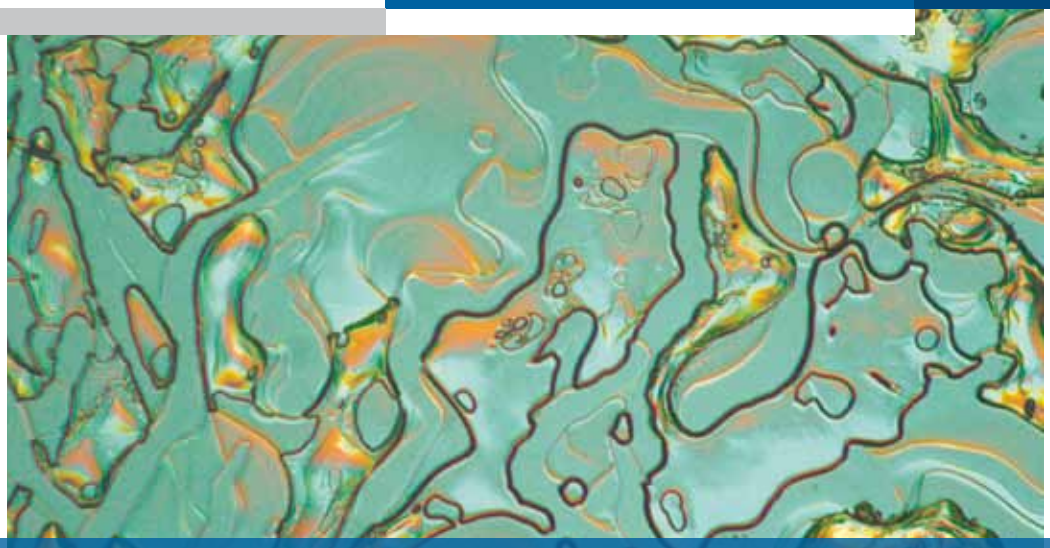
ERC Starting Grant of the European Research Council (ERC)
Dr. Thorsten Wiegand, Dr. Andreas Huth, Helmholtz Centre for Environmental Research – UFZ

Wilhelm Exner Medal, Austria
Prof. Dr. Christian Wandrey, Former Institute Director, Forschungszentrum Jülich

FI **Fellow of the American Physical Society, USA**
Prof. Dr. Ulf-G. Meißner, Forschungszentrum Jülich

Forschungspreis der Fürst-Donnersmarck-Stiftung
Prof. Dr. Gereon R. Fink, Forschungszentrum Jülich

GI **Brigitte Gedek Science Award of the Society for Mycotoxin Research**
Dr. Tobias Polte, Helmholtz Centre for Environmental Research – UFZ together with the Clinic and Policlinic for Dermatology, Allergology and Venerology of the University Leipzig



SILICON PROBE UNDER THE POLARISING MICROSCOPE: THIS IS HOW SURFACE STRUCTURES CAN BE EXAMINED IN DETAIL AND THIN-LAYER SOLAR CELLS CAN BE OPTIMISED FOR ENERGY PRODUCTION. Photo: HZB

Last update: September 2010

International Prize Gerolamo Cardano
Prof. Dr. Dr. Pierluigi Nicotera, German Centre for Neurodegenerative Diseases (DZNE)

GlaxoSmithKline-Wissenschaftspreis für Medizinische Grundlagenforschung
Prof. Dr. Norbert Hübner, Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch

HI
Acceptance into the „Hall of Fame of German Research"
Prof. Dr. Peter Grünberg, Formerly Forschungszentrum Jülich

Walter Hälg Prize 2009
Prof. Dr. Dieter Richter, Forschungszentrum Jülich

Hector Fellow of the Hector Foundation II
Prof. Dr. Manfred Kappes, Prof. Dr. Franz Nestmann, Karlsruhe Institute of Technology

Gay Lussac Humboldt Prize 2009
Prof. Dr. Claus M. Schneider, Forschungszentrum Jülich

MI
Paul Martini Preis 2010
Dr. Jürgen Ruland, Helmholtz Zentrum München - German Research Center for Environmental Health, together with **Prof. Dr. Veit Hornung,** University Clinic Bonn.

Marine Research Prize of the Institute of Marine Sciences
Prof. Dr. Karin Lochte, Alfred Wegener Institute for Polar and Marine Research

SI
Dale Sayers Prize of the International X-ray Absorption Society (IXAS)
Dr. Emad Flear Aziz Bekhit, Helmholtz-Zentrum Berlin für Materialien und Energie

Schillerpreis 2009 der Stadt Marbach am Neckar
Prof. Dr. Jens Reich, Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch

Erwin Schrödinger Prize 2010
Prof. Dr. Hauke Harms, Dr. Mona C. Wells, Helmholtz Centre for Environmental Research – UFZ, together with **Prof. Dr. Jan-Roelof van der Meer,** University Lausanne

TI
Tate Medal, American Institute of Physics (AIP)/ American Physical Society
Prof. Gustav-Adolf Voss, Former Director Deutsches Elektronen-Synchrotron DESY

VI
1st Prize at the VentureCup Mecklenburg-Vorpommern
Dr. Robert Brockmann and team, Max Planck Institute for Plasma Physics

WI
Marcus Wallenberg Preis des Jahres 2010
Prof. Dr.-Ing. Hans Joachim Blaß, Karlsruhe Institute of Technology

Wilhelm Warner Preis 2009
Prof. Dr. Jürgen Ruland, Helmholtz Zentrum München - German Research Center for Environmental Health and Technical University Munich

Carl Friedrich von Weizsäcker Preis of the National Academy of Sciences Leopoldina and of the Stifterverband für die Deutsche Wissenschaft
Prof. Jens Reich, Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch

Berliner Wissenschaftspreis des Regierenden Bürgermeisters
Prof. Dr. Nikolaus Rajewsky, Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch

Women in Science Award of the European Molecular Biology Organisation EMBO/Federation of European Biochemical Societies FEBS
Prof. Dr. Ingrid Grummt, German Cancer Research Centre

THE GOVERNANCE STRUCTURE OF THE HELMHOLTZ ASSOCIATION

COMMITTEE OF THE 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. In the Senate, all important decisions are discussed. The Senate elects the president and the vice-presidents.

SENATE COMMISSION

The Senate established the Senate Commission to prepare its deliberations on the funding of the programmes, based on the results of the programme reviews, and its decision on investment prioritisation. The Senate Commission consists 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.

HEAD OFFICE

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

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. The administrative section is represented by two administrative vice-presidents.

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

RESEARCH FIELDS

In six research fields doing research on the basis of Programme-oriented Funding, Helmholtz scientists cooperate across centres with external partners – interdisciplinary and internationally.

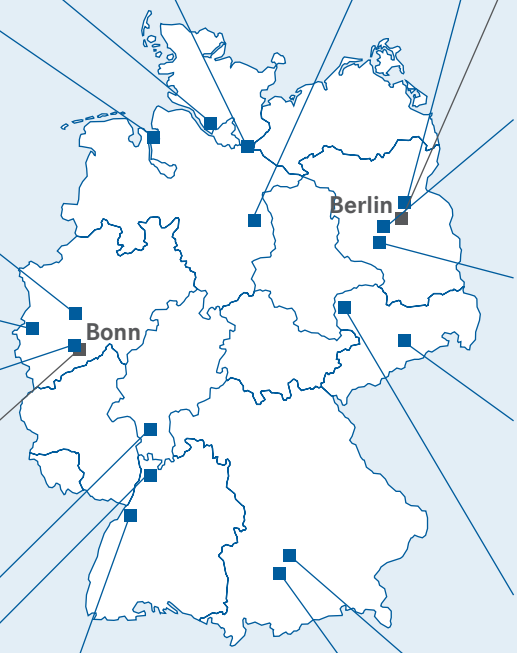
ASSEMBLY OF MEMBERS

The Helmholtz Association is a registered association, its members are 15 (as of 1 January 2011 16 with the Research Centre Dresden-Rossendorf) legally independent research centres and one associated member. The Association's central body – apart from the Senate – is the Assembly of Members, consisting of one scientific-technical and one administrative director each from the member centres. The Assembly of Members is responsible for all duties of the registered association. 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
- German Cancer Research Centre
- German Aerospace Centre (DLR)
- German Centre for Neurodegenerative Diseases (DZNE)
- Forschungszentrum Jülich
- Helmholtz-Zentrum Geesthacht[1)] Centre for Materials and Coastal Research
- GSI Helmholtz Centre for Heavy Ion Research
- Helmholtz-Zentrum Berlin für Materialien und Energie
- Helmholtz Centre for Infection Research
- Helmholtz Zentrum München – German Research Center for Environmental Health
- Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences
- Helmholtz Centre for Environmental Research – UFZ
- Karlsruhe Institute of Technology
- Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch
- Max Planck Institute for Plasma Physics (Associate Member)

[1)] By 31 October 2010 GKSS Research Centre Geesthacht

SITES OF THE HELMHOLTZ RESEARCH CENTRES



Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research[1)]
www.hzg.de

Deutsches Elektronen-Synchrotron DESY
www.desy.de

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

German Aerospace Centre (DLR)
Köln (headquaters)
www.DLR.de

Forschungszentrum Jülich
www.fz-juelich.de

German Centre for Neuro-degenerative Diseases (DZNE)
www.dzne.de

Helmholtz Associaton Reg. Office Bonn
www.helmholtz.de

GSI Helmholtz Centre for Heavy Ion Research
www.gsi.de

German Cancer Research Centre
www.dkfz.de

Karlsruhe Institute of Technology
www.kit.de

Helmholtz Centre for Infection Research
www.helmholtz-hzi.de

Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch
www.mdc-berlin.de

Helmholtz Association Head Office Berlin
www.helmholtz.de

Helmholtz-Zentrum Berlin für Materialien und Energie
www.helmholtz-berlin.de

Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences
www.gfz-potsdam.de

Research Centre Dresden-Rossendorf
(as of 1 January 2011 Helmholtz Centre Dresden-Rossendorf and member of the Helmholtz Association)

Helmholtz Centre for Environmental Research – UFZ
www.ufz.de

Max Planck Institute for Plasma Physics
(associate member)
www.ipp.mpg.de

Helmholtz Zentrum München – German Research Center for Environmental Health
www.helmholtz-muenchen.de

[1)] By 31 October 2010 GKSS Research Centre Geesthacht

MEMBER CENTRES

ALFRED-WEGENER-INSTITUT FÜR POLAR- UND MEERESFORSCHUNG
ALFRED WEGENER INSTITUTE FOR POLAR AND MARINE RESEARCH

DIRECTORATE: Prof. Dr. Karin Lochte, Director, Dr. Heike Wolke, Administrative Director
Members of the Directorate:
Prof. Dr. Heinrich Miller, Prof. Dr. Karen Helen Wiltshire
Am Handelshafen 12, 27570 Bremerhaven
Telephone +49 471 4831-0, Telefax +49 471 4831-1149
E-mail info@awi.de, www.awi.de

DEUTSCHES ELEKTRONEN-SYNCHROTRON DESY

DIRECTORATE: Prof. Dr. Helmut Dosch, Chairman of the Board of Directors, Christian Scherf, Administrative Director, Dr. Reinhard Brinkmann, Director of the Accelerator Division, Prof. Dr. Joachim Mnich, Director in charge of High EnergyPhysics and Astroparticle Physics, Prof. Dr. Edgar Weckert, Director in charge of Photon Science
Notkestraße 85, 22607 Hamburg
Telephone +49 40 8998-0, Telefax +49 40 8998-3282
E-mail desyinfo@desy.de, www.desy.de

DEUTSCHES KREBSFORSCHUNGSZENTRUM
GERMAN CANCER RESEARCH CENTRE

EXECUTIVE BOARD: Prof. Dr. Otmar D. Wiestler, Chairman of the Management Board and Scientific Director, Dr. Josef Puchta, Administrative Director
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Telephone +49 6221 42-0, Telefax +49 6221 42-2995
E-mail presse@dkfz.de, www.dkfz.de

DEUTSCHES ZENTRUM FÜR LUFT- UND RAUMFAHRT
GERMAN AEROSPACE CENTRE (DLR)

EXECUTIVE BOARD: Prof. Dr.-Ing. Johann-Dietrich Wörner, Chairman of the Executive Board, Klaus Hamacher, Vice-Chairman of the Executive Board, Members of the Executive Board: Thomas Reiter, Prof. Rolf Henke, Prof. Dr.-Ing. Ulrich Wagner
Linder Höhe, 51147 Köln
Telephone +49 2203 601-0, Telefax +49 2203 67310
E-mail kommunikation@DLR.de, www.DLR.de

DEUTSCHES ZENTRUM FÜR NEURODEGENERATIVE ERKRANKUNGEN (DZNE)
GERMAN CENTRE FOR NEURODEGENERATIVE DISEASES (DZNE)

EXECUTIVE BOARD: Prof. Dr. Dr. Pierluigi Nicotera, Scientific Director and Chairman of the Executive Board, Ursula Weyrich, Administrative Director
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E-mail information@dzne.de, www.dzne.de

FORSCHUNGSZENTRUM JÜLICH

EXECUTIVE BOARD: Prof. Dr. Achim Bachem, Chairman of the Board of Directors, Dr. Ulrich Krafft, Deputy Chairman of the Board of Directors,
Members of the Board of Directors:
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Wilhelm-Johnen-Straße, 52428 Jülich
Telephone +49 2461 61-0, Telefax +49 2461 61-8100
E-mail info@fz-juelich.de, www.fz-juelich.de

HELMHOLTZ-ZENTRUM GEESTHACHT ZENTRUM FÜR MATERIAL- UND KÜSTENFORSCHUNG
HELMHOLTZ-ZENTRUM GEESTHACHT CENTRE FOR MATERIALS AND COASTAL RESEARCH

(By 31 October 2010 GKSS Research Centre Geesthacht)
DIRECTORATE: Prof. Dr. Wolfgang Kaysser, Scientific-Technical Director, Michael Ganß, Administrative Director
Max-Planck-Straße 1, 21502 Geesthacht
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E-mail presse@hzg.de, www.hzg.de

GSI HELMHOLTZZENTRUM FÜR SCHWERIONENFORSCHUNG
GSI HELMHOLTZ CENTRE FOR HEAVY ION RESEARCH

DIRECTORATE: Prof. Dr. Horst Stöcker, Scientific Director, N.N., Administrative Director, Dr. Hartmut Eickhoff, Technical Director
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HELMHOLTZ-ZENTRUM BERLIN FÜR MATERIALIEN UND ENERGIE

DIRECTORATE: Prof. Dr.-Ing. Anke Rita Kaysser-Pyzalla, Scientific Director, Prof. Dr. Wolfgang Eberhardt, Scientific Director, Dr. Ulrich Breuer, Administrative Director
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HELMHOLTZ-ZENTRUM FÜR INFEKTIONSFORSCHUNG

HELMHOLTZ CENTRE FOR INFECTION RESEARCH
DIRECTORATE: Prof. Dr. Jürgen Wehland, Scientific Director (deceased on 16 August 2010), Ulf Richter, Administrative Director
Inhoffenstraße 7, 38124 Braunschweig
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E-mail kontakt@helmholtz-hzi.de, www.helmholtz-hzi.de

HELMHOLTZ ZENTRUM MÜNCHEN – DEUTSCHES FORSCHUNGSZENTRUM FÜR GESUNDHEIT UND UMWELT

HELMHOLTZ ZENTRUM MÜNCHEN – GERMAN RESEARCH CENTRE FOR ENVIRONMENTAL HEALTH
DIRECTORATE: Prof. Dr. Günther Wess, Scientific Director, Dr. Nikolaus Blum, Administrative Director
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E-mail presse@helmholtz-muenchen.de, www.helmholtz-muenchen.de

HELMHOLTZ-ZENTRUM POTSDAM DEUTSCHES GEOFORSCHUNGSZENTRUM GFZ

HELMHOLTZ CENTRE POTSDAM
GFZ GERMAN RESEARCH CENTRE FOR GEOSCIENCES
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E-mail presse@gfz-potsdam.de, www.gfz-potsdam.de

HELMHOLTZ-ZENTRUM FÜR UMWELTFORSCHUNG – UFZ

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ
DIRECTORATE: Prof. Dr. Georg Teutsch, Scientific Director, Dr. Andreas Schmidt, Administrative Director
Permoserstraße 15, 04318 Leipzig
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E-mail info@ufz.de, www.ufz.de

KARLSRUHER INSTITUT FÜR TECHNOLOGIE

KARLSRUHE INSTITUTE OF TECHNOLOGY
EXECUTIVE BOARD: Presidents: Prof. Dr. Horst Hippler, Prof. Dr. Eberhard Umbach, Vice-Presidents: Dr. Peter Fritz, Dr. Alexander Kurz, Prof. Dr. Detlef Löhe
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Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen
Telephone +49 7247 82-0, Telefax +49 7247 82-5070
E-mail info@kit.edu, www.kit.edu

MAX-DELBRÜCK-CENTRUM FÜR MOLEKULARE MEDIZIN (MDC) BERLIN-BUCH

MAX DELBRÜCK CENTER FOR MOLECULAR MEDICINE (MDC) BERLIN-BUCH
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Robert-Rössle-Straße 10, 13125 Berlin-Buch
Telephone +49 30 9406-0, Telefax +49 30 949-4161
E-mail presse@mdc-berlin.de, www.mdc-berlin.de

MAX-PLANCK-INSTITUT FÜR PLASMAPHYSIK

MAX PLANCK INSTITUTE FOR PLASMA PHYSICS
(Associate Member)
DIRECTORATE: Prof. Dr. Günther Hasinger, Chairman and Scientific Director, Christina Wenninger-Mrozek, Administrative Director, Members of the Directorate: Prof. Dr. Sibylle Günter, Prof. Dr. Thomas Klinger, Dr. Rem Haange (consultative function)
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