HELMHOLTZ – GENERATING KNOWLEDGE FOR THE DIGITAL WORLD

ANNUAL REPORT 2014

THE HELMHOLTZ ASSOCIATION OF GERMAN RESEARCH CENTRES

Research in Germany
Land of Ideas

HELMHOLTZ
ASSOCIATION

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NOTE ON THE REPORTING PERIOD

The Helmholtz Annual Report 2014 describes developments at the Helmholtz Association between 2013 and August 2014. It shows the actual costs of research in 2013 and the Helmholtz Senate's financing recommendations for 2015–2019 for the programmes in energy research, key technologies research and matter research. The report also presents the financing recommendations for the programme period 2010–2014 for the research fields Earth and Environment, Health, and Aeronautics, Space and Transport.

The Annual Report can be downloaded as a PDF at www.helmholtz.de/en/gb14

Cover image: iStockphoto/Strandperle; KIT; NASA; HZI; FZJ; GSI; DLR

We contribute to solving the major and pressing problems of society, science and industry by conducting high-level research in the strategic programmes of our six research fields: Energy, Earth and Environment, Health, Aeronautics, Space and Transport, Key Technologies, and the Structure of Matter.

We research highly complex systems in cooperation with national and international partners using our large-scale facilities and scientific infrastructure.

We are committed to shaping our shared future by combining research and technological developments with innovative applications and prevention strategies.

This is our mission.

DIVERSITY

“We were able to show that the SORLA protein produced by nerve cells protects people against Alzheimer’s. It keeps the brain from producing too many A-beta protein fragments, which damage nerve cells. Because of genetic changes, Alzheimer’s patients have too little SORLA, which means that their nerve cells produce too much A-beta. We are now looking for drugs that stimulate the production of SORLA in human neurons. We hope that they will help us to protect people against Alzheimer’s.”

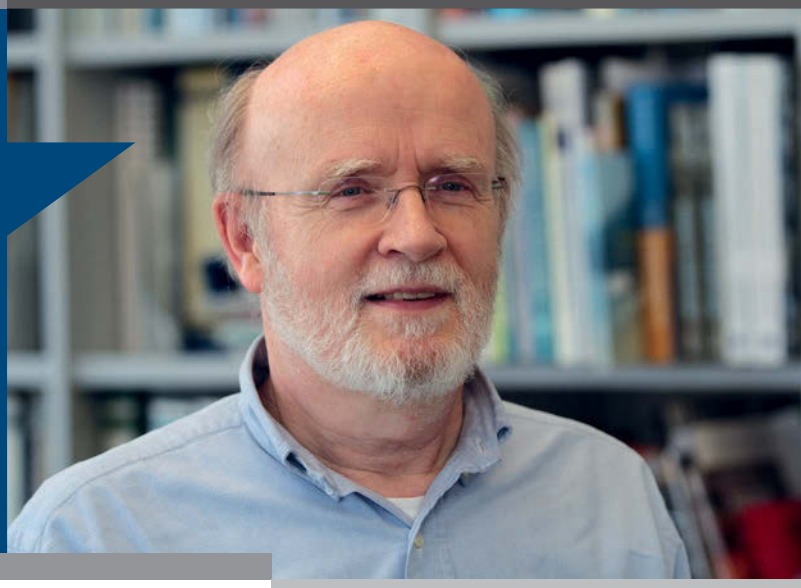
PROFESSOR THOMAS WILLNOW
heads the Molecular Cardiovascular Research Group at the Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch

“Catalysts are not only used in cars, but are an important factor in the chemical industry because they are able to reduce reaction energy. Working at the PETRA III X-ray source, we have developed a technique that enables us to use extremely short-wave X-ray light and powerful large-scale detectors to investigate atomic processes on a catalyst surface in real time. With this method we can contribute to developing less expensive, optimised catalysts.”

PROFESSOR ANDREAS STIERLE
is a senior scientist at the Deutsches Elektronen-Synchrotron DESY and directs the DESY Nanolab

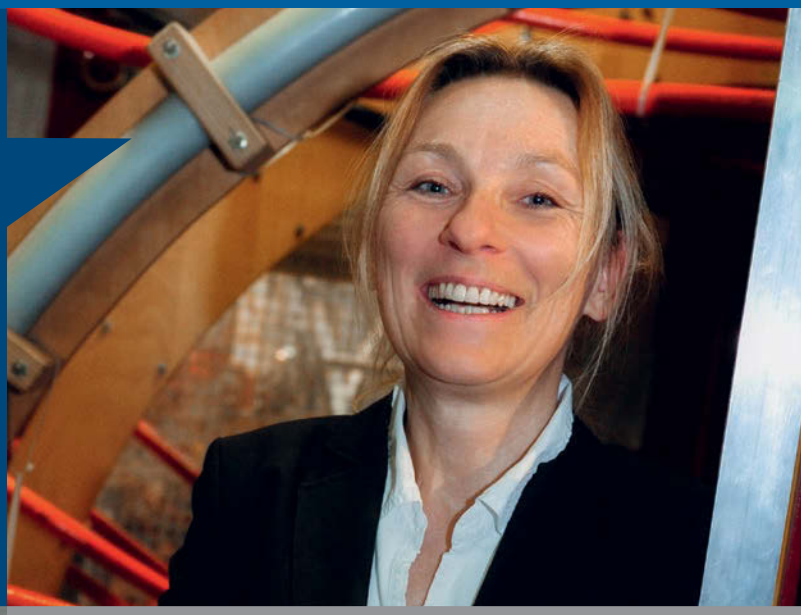
“In the course of evolutionary history, periods of extreme climate change have repeatedly led to severe crises, and the changes we are currently experiencing in the climate have the potential to end the same way. Despite all the worries, though, studying the effects of climate change on life in general and its impact over geological time is extremely exciting. Our central focus is the physiology of organisms because it brings together disciplines such as climate physics, ecology, biogeochemistry, palaeobiology and ultimately also human biology.”

PROFESSOR HANS-OTTO PÖRTNER
directs the Integrative Ecophysiology Section of the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research



“We are developing the heating system that will heat plasma fuel to ignition temperature at the international fusion test reactor ITER. Fast hydrogen atoms injected into the plasma transmit their energy to plasma particles via collisions. Using this method, we can achieve a temperature many times hotter than the sun. We are also designing a heating system for a future demonstration plant and are thus laying the foundation for a fusion power plant.”

PROFESSOR URSEL FANTZ
directs the ITER Technology and Diagnostics Division of the Max Planck Institute for Plasma Physics, an associate member of the Helmholtz Association



“It was a radical step to return to Germany from the United States after a stay of almost 25 years, but the prospects awaiting me in Berlin were fantastic. The new EMIL laboratory at BESSY II will offer opportunities that previously did not exist. Here we can combine different measurement techniques and directly investigate materials such as the thin layers in solar cells during their growth process.”

DR. SIMONE RAOUX
directs the institute Nanospectroscopy for the Design and Optimisation of Energy-Relevant Materials at the Helmholtz-Zentrum Berlin

“We want to assess how much of the global mineral resources are really available on the ocean floor. Some locations are already known, in particular active hydrothermal vents and manganese nodule areas, but on this limited basis it is difficult to make a global estimate. In addition, we need to find deposits that have a size sufficient to make a real difference to global metal supply.”

PROFESSOR MARK HANNINGTON
directs the Marine Mineral Resources Research Group at the GEOMAR Helmholtz Centre for Ocean Research Kiel

Professor Dr. Jürgen Mlynek, President

HELMHOLTZ – GENERATING KNOWLEDGE FOR THE DIGITAL WORLD

Dear Reader,

The Internet has triggered a digital revolution. It has torn down borders and accelerated the pace of our lives. We can now access almost any type of information at any time and nearly anywhere. This profound transformation is changing society, the economy and – in a very direct and comprehensive way – science and research. Vast quantities of data are now available to the entire research community in real time. The unforeseen possibilities of "big data" are creating new challenges. Conventional storage media can no longer absorb this deluge of information, and processing it is consuming an ever-growing share of our energy resources. New technologies and mathematical calculation methods are required to cope with these huge quantities of data. This is where Helmholtz research comes in. Whether it is the question of the rapid digitisation of society, working on new treatments for common diseases or structuring the transition to a cleaner energy regime, our goal is not only to keep pace with ongoing developments, but to prepare society for future challenges by means of forward-looking strategic research. This annual report provides you with information on the most important innovations at the Helmholtz Association in fiscal year 2013. Using many examples of research at the Helmholtz centres, it introduces our research fields and describes the third round of reviews within the scope of programme-oriented funding.

Wishing you enjoyable reading,

Jürgen Mlynek

PRESIDENT'S REPORT

"CHANGE IS A CONSTANT INCENTIVE FOR US AND AN INTEGRAL PART OF OUR MISSION."

Jürgen Mlynek

The rapid digitisation of nearly all areas of our lives over the past 20 years shows just how quickly society, the economy and science can change – and how important it is to contribute to this transformation process as a scientific research organisation. The Helmholtz Association is synonymous with research into the major topics that will shape the future. While we cannot predict the future, we should regularly ask ourselves whether we are researching the right topics, those that will be crucial for our society in the next 20 years and beyond. We are always focused on the important goal of conducting research that points the way forward.

Strategic research under review

We should constantly check whether our research infrastructure, especially our large-scale devices, is well suited to meet the most pressing social and economic challenges of the day. How does our research rate in international comparison? Are we recruiting the right staff and how successful are we in retaining them? In 2013 and 2014, a total of 419 internationally recognised, independent experts – including 318 from abroad – helped us to answer these questions. They took part in a process held at five-year intervals to evaluate the Helmholtz Association's research activities. We call this process programme-oriented funding (POF). It combines the strategic question of the proper research theme with the question of research quality. In 2004, the Helmholtz Association began allocating its research funds to strategically oriented research programmes that span disciplines and member centres. The strategic guidelines required for this process, defined in research policy requirements, are formulated by the funding bodies and representatives of government working together with the Helmholtz Association.

In spring 2013, the third round of POF reviews began for programmes in three of the association's six research fields: Earth and Environment, Health, and Aeronautics, Space and Transport. In October 2013, the Helmholtz Senate decided to provide these research fields with funding of 6.16 billion euros for the period from 2014 to 2018. Reviews of the three remaining fields – Energy, Key Technologies and the Structure of Matter – followed in spring 2014. The evaluations targeted many of the large-scale facilities operated by the Helmholtz Association, including synchrotrons, particle accelerators and fusion reactors. For these research fields the Helmholtz Senate has now approved funding of 6.63 billion euros for the period from 2015 to 2019. In both rounds of reviews, experts confirmed the outstanding quality of Helmholtz research and its great strategic relevance for the scientific community, industry and society.

After ten years of implementation and three rounds of reviews, the instrument of programme-oriented funding itself is being evaluated. A working group established by the German Council of Science and Humanities launched the process in spring 2014 with the aim of securing the

Selected highlights from the reporting period

2013

14 Jan 2013
The Helmholtz Association establishes 100th virtual institute

15 Jan 2013
Helmholtz launches new programme to fund Helmholtz International Research Groups

28 Jan 2013
The EU funds Human Brain Project as flagship venture at the Helmholtz Association

7 Feb 2013
Start of the third round of research programme reviews by 200 international experts

11 March 2013
Opening in Berlin of the travelling exhibition "Ideas 2020 – A Tour of Tomorrow's World"

6 June 2013
Decision to establish the Helmholtz Institute Erlangen-Nürnberg for Renewable Energy Production

18 June 2013
Opening of the Berlin Institute of Health, operated by the MDC and the Charité

Helmholtz Association's capacity for strategic action against the backdrop of an ever-evolving research system. At the same time, the working group is addressing the question of the future role of the Helmholtz Association in the increasingly interconnected scientific community in Europe and across the world. In order to answer these questions, the Council of Science and Humanities is examining the efficacy and efficiency of the method of programme-oriented funding, including its governance structures, instruments and processes. In fall 2015, it will issue recommendations as to how the Helmholtz Association can improve its allocation of funds in view of the present conditions and requirements of the research system.

Large-scale research infrastructure as a unique feature

A unique feature of the Helmholtz Association is its commitment to developing and operating modern large-scale research facilities as well as to making these facilities – some of which are unparalleled in the world – available to the international scientific community. As part of the National Roadmap, a pilot project initiated by the Federal Ministry of Education and Research, the Helmholtz Association is developing a key-issues paper on the future processes of prioritising, planning, constructing and operating international research infrastructure. The paper's central points include transparency and binding obligations with respect to the risks assumed by the Helmholtz centres; the assurance of an appropriate balance between the research conducted in programmes, on the one hand, and the construction and operation of major large-scale facilities, on the other; and the responsibility assumed by both the centres and the association when planning and managing such large-scale projects. In addition, the paper addresses the question of how all the major organisations in the German research system can be involved in developing a National Roadmap in the future.
In early 2014, the German federal government and the federal state of Hesse entered into an agreement to establish the International Helmholtz Center for the Facility for Antiproton and Ion Research (HIC for FAIR). For this purpose, the GSI Helmholtz Centre for Heavy Ion Research GmbH and FAIR GmbH will merge as quickly as possible to form a joint organisation.

The association further expands its collaborations

In its numerous collaborations, the Helmholtz Association works together in various ways with partners in the research system. These collaborations take place not only at the national but also the international level – the association's research facilities are made available to scientists from around the world. In 2013, for example, more than 2,600 visiting scientists from outside Germany conducted research at the Helmholtz centres. After approval by the Helmholtz Senate and a positive evaluation of submitted plans, a new Helmholtz institute was inaugurated in Münster in June 2014. Called the Helmholtz Institute Münster – Ionics in Energy Storage, this facility is a collaboration between the Forschungszentrum Jülich, the University of Münster and RWTH Aachen University, and will devote itself to battery research. The Helmholtz Association has committed itself to providing 5.5 million euros in annual funding, while the federal state of North Rhine-Westphalia will invest an additional 11 million euros by 2018. Research at the new institute will centre on electrolytes and their ionic behaviour and will complement work at the Helmholtz Institute Ulm – Electrochemical Energy Storage. With these focuses we intend to make a major contribution to the transition to a clean energy regime. In addition, in the period under review, three Helmholtz institutes held topping-out ceremonies to mark the construction of new buildings at the Helmholtz institutes in Ulm, Saarbrücken and Mainz, all of which involve cooperation with at least one university.
In March 2014 the first three major research projects will be launched at the new Berlin Institute of Health, jointly operated by the Max Delbrück Center for Molecular Medicine (a member of the Helmholtz Association) and Charité – Universitätsmedizin Berlin. The Helmholtz Association will fund the institute with a total of 45 million euros during its initial years. The German Centres for Health Research, in which

22 June 2013
Helmholtz funds 15 Helmholtz International Research Groups

30 Sept 2013
Helmholtz supports five German Chinese research projects

7 Oct 2013
Helmholtz selects three research projects to be commercialised

11 Oct 2013
The Helmholtz office in Beijing celebrates its 10th anniversary

22 Oct 2013
Successful evaluation of the planned Helmholtz Institute in Münster

9 Dec 2013
Start-up assistance for marketable research: Helmholtz supports four spin-offs

9 Dec 2013
Second "Innovation Days" with Germany's leading research organisations and industry

"QUALIFIED AND DEDICATED STAFF ARE A SCIENTIFIC ORGANISATION'S MOST VALUABLE ASSET."

Jürgen Mlynek

the Helmholtz Association is playing a major role, are also being expanded. In 2013 alone, the federal and state governments invested 77 million euros in these centres, which are expected to be completed by 2015.

People are our most valuable asset

One of the Helmholtz Association's strategic focuses is talent management – after all, suitable staff are a scientific organisation's most valuable asset. With the help of various initiatives, including several that support young scientists, Helmholtz is continually developing staff potential. The Helmholtz Academy for Leadership, which was founded in 2007 and teaches management methods for the effective use of internal resources, is being further expanded. The academy's core curriculum covers strategy development, structure and process organisation, as well as staff management. The recruitment initiative launched in 2011 to acquire outstanding scientists is also making a significant contribution to attracting the most suitable staff to the association. One of the initiative's goals is to achieve a quota of at least 30 per cent women and so far this target has been exceeded. Overall, the Helmholtz Association provides an annual budget of 24 million euros to the recruitment initiative. In order to increase the share of women in top positions, Helmholtz is also implementing the W2/W3 programme for outstanding female scientists. Resources from the Initiative and Networking Fund make it possible to finance at least five new W2/W3 positions a year. Talent management also targets the youngest members of society: the Little Scientist's House foundation now supports more than 230 local partners with its structures and offerings – reaching 26,500 day care centres, after school centres and primary schools throughout Germany. In addition, each year the school labs at Helmholtz centres and cooperating universities, now totalling 30, attract 65,000 school pupils, hundreds of university students and more than 2,000 teacher trainees.

The right political framework

The Academic Freedom Act, passed in December 2012, grants research organisations more latitude when making budgetary and personnel decisions, taking stakes in firms and carrying out construction projects. It thus expands the organisations' capacity to act and eliminates red tape. In addition, in the period under review, the Helmholtz Association worked together with the boards of its member centres to introduce variable remuneration elements based on target agreements. The personnel committees of the centres' supervisory boards will now adapt the target agreements to the individual centres while keeping the association's overall goals in mind.
In the current legislative period, an additional nine billion euros has been earmarked for science and education, with three billion of this sum going to research. The five-year Joint Initiative for Research and Innovation is being continued in its third phase, albeit with only a three per cent increase in annual funding for non-university research organisations as compared to the previous five per cent. This is because the German government will have to shoulder these increases without the help of the federal states. When the governing grand coalition finally fulfils its pledge to lift the ban on collaborations within the research system, it will become much easier to implement new collaborative models between university and non-university research organisations. It will mean, for instance, that federal funds can be permanently allocated to underfinanced universities and bolster efforts to ensure an adequate reservoir of young scientists.

The aim of this brief report has been to illustrate that the Helmholtz Association is in a state of constant change. Just as the world is changing all around us and new challenges are constantly emerging, so too is the Helmholtz Association changing. For us, this change is a constant incentive. Any organisation that sets itself the goal of solving major social problems requires a great deal of patience as it moves towards success. I am convinced that the Helmholtz Association will continue to meet the high expectations that have been placed upon it.

2014

12 March 2014
Rainer Waser from the Forschungszentrum Jülich wins Leibniz Prize 2014

11 April 2014
A signal for qualified research staff: presentation of the first Helmholtz DKB Apprenticeship Award

23 April 2014
50th anniversary of the German Cancer Research Center: Chancellor Merkel is guest of honour in Heidelberg

9 May 2014
5th anniversary of the German Center for Neurodegenerative Diseases (DZNE)

10 June 2014
Establishment of the Helmholtz Institute in Münster as an excellence centre for battery research

27 June 2014
Eight outstanding scientists receive Helmholtz International Fellow Award

29 Aug 2014
DESY lays foundation stone for unique infection research centre

JOINT INITIATIVE FOR RESEARCH AND INNOVATION

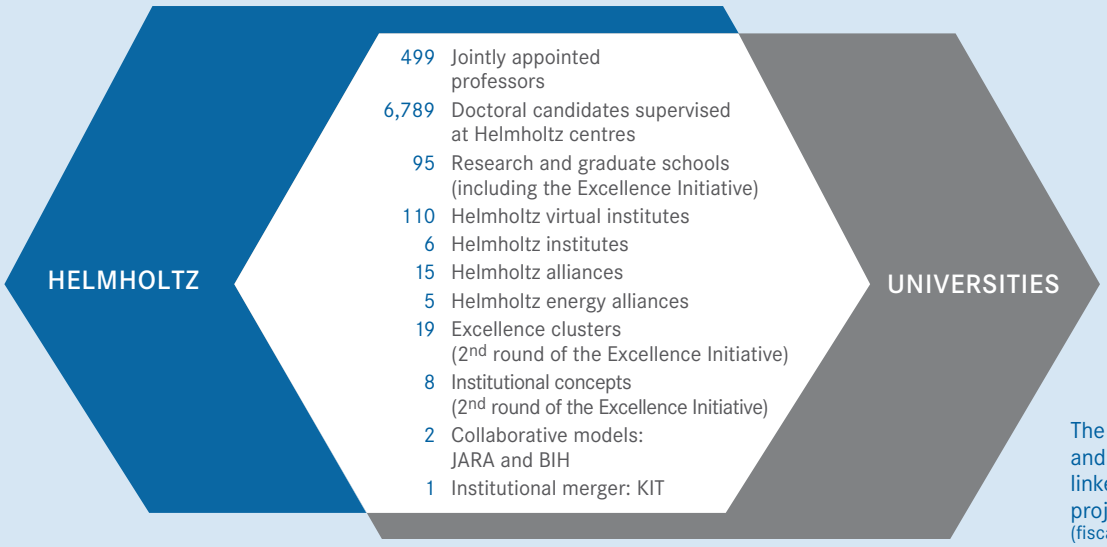
The Joint Initiative for Research and Innovation guarantees the Helmholtz Association and other non-university research organisations a budget through 2015 with increases of five per cent per year. With this programme, Germany's federal and state governments have created optimal conditions for developing the participating research organisations. The report on the following pages describes how the Helmholtz Association is fulfilling the initiative's objectives.

New research fields with a strategic importance

The Helmholtz Association is committed to conducting socially relevant research and addressing the major challenges facing society, science and industry today. To meet these goals, at five-year intervals the association systematically reviews the portfolio of research topics that were core-financed within the framework of programme-oriented funding. The new programme structure derived from these reviews is also a result of the comprehensive thematic planning process that began in all of the association's research fields in 2010. Sixteen of these new research topics were allocated funding from the Joint Initiative for Research and Innovation so that the work on these topics could begin before the start of the new 2014/15 programme period.

Pooling expertise by building networks within the research system

Science thrives on collaboration and the exchange of ideas. The Helmholtz Association has used funding from the Joint Initiative for Research and Innovation to establish a wide range of collaborative models, from temporary networks in which project partners pursue a common goal at different locations to permanent structures such as the Helmholtz institutes. The latter are branches of the Helmholtz centres set up on the campus of a university partner. The Joint Initiative has made it possible to provide targeted support for these new structures. Via joint projects, the partner universities benefit from the funds that the Helmholtz Association has received from the Joint Initiative. In many cases the Helmholtz Association's Initiative and Networking Fund provides start-up assistance for network-building initiatives through its own funding instruments. In the Helmholtz alliances and virtual institutes, the Helmholtz centres pool their expertise with universities and non-university partners in order to achieve rapid progress and international visibility in strategically important research areas. In 2013 two new alliances commenced their work: the energy alliance "Technologies for the Future Energy Grid", funded with 3.2 million euros for two years, and the alliance "Preclinical Comprehensive Cancer Center", allocated a total of five million euros for a period of four years. In contrast to the Helmholtz alliances, the virtual institutes are smaller, flexible structures that will draw on international expertise and address specific research topics together with university partners. From the Initiative and Networking Fund they receive funding of up to 600,000 euros a year for



The Helmholtz Association and its university partners: linked through people, projects and institutions
(fiscal year 2013)

a three- to five-year period. This is supplemented by grants from the centres, meaning that the research projects can be financed with up to 900,000 euros per year. These models demonstrate that creating networks within the research system continues to be a core element of the Helmholtz strategy. The Berlin Institute of Health (BIH) is the most recent example of a regional collaboration that brings together the cutting-edge research being carried out at the Helmholtz centres and German universities.

New impetus from international networks

A large number of Helmholtz networks have an international scope, as do many of the Helmholtz alliances and virtual institutes. The portfolio of funding instruments has recently been expanded to include not only grants for research groups but also individual-based funding in the form of the Helmholtz International Fellow Award. With the new Helmholtz International Research Groups, the Helmholtz Association is supporting cooperation between its centres and foreign research institutions. These groups give young researchers, in particular, the opportunity to gain initial experience with international collaboration. The Helmholtz International Research Groups establish joint research teams with foreign partner institutions. From the Initiative and Networking Fund they receive up to 50,000 euros annually for an initial period of three years, with the foreign partner institutions contributing the same level of funding. In 2013 Helmholtz selected a total of 15 international research groups within the framework of a pilot project. The Helmholtz International Fellow Award targets outstanding scientists and science managers outside Germany who have excelled in fields that are relevant to the association. In addition to receiving prize money of 20,000 euros, the scientists are invited to conduct research flexibly at one or more of the Helmholtz centres and give talks in the Helmholtz Academy. So far a total of 36 individuals have been honoured with this award.

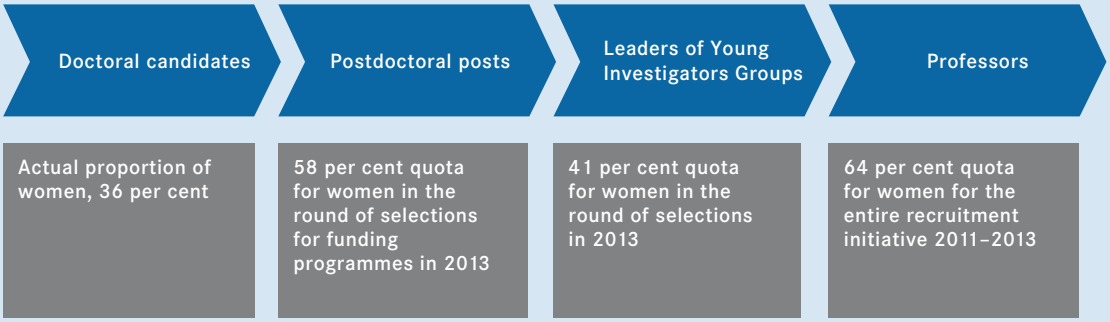
Talent management: attracting and promoting the best staff

Research organisations depend on the creativity and quality of their staff. Attracting, promoting and retaining the best people remains a top priority at the Helmholtz Association. This is why it uses part of the budgetary increases from the Joint Initiative for Research and Innovation to attract top scientists, particularly top female scientists. A total of 102 million euros has been earmarked for this purpose for 2013 to 2017.

For its scientific personnel the Helmholtz Association has established a fixed quota system based on a “cascading” model. The goal of the system is to acquire more women for leadership positions above and beyond those hired through the association’s recruitment initiative. In this model the targeted participation rate for women at a specific stage in their career is determined by the proportion of women in the previous career stage. With this combination of clearly formulated objectives and expanded capacities, the Helmholtz Association is continuing to make a determined effort to recruit more female scientists.

In addition to recruiting top scientists, the association has expanded its efforts to promote young researchers. It funds graduate and research schools at the Helmholtz centres as a way of establishing structured graduate education throughout the country, and it also makes grants available through the proven Helmholtz Young Investigators Groups. In addition,

More women in leadership positions as a result of support along the talent chain



Programme reviews: the quota for experts has been set at 30 per cent for all competitions for funds

In its "cascading" model the Initiative and Networking Fund provides a number of funding instruments for postdoctoral women scientists. The Helmholtz Association is using this model to counter the declining proportion of women in senior positions and to achieve the targeted quotas.

in 2013 the association launched a second call for applications for the Helmholtz Postdoc Programme. The 19 candidates selected for grants will receive up to 300,000 euros each for two to three years in order to establish themselves in their respective research fields. Thanks to the Joint Initiative for Research and Development, a well-rounded funding portfolio has emerged that covers all the important links in the talent chain, from doctoral candidate to professor. The association pursues a two-pronged strategy for every stage of a scientist's career: opening up prospects for the best scientists through additional capacities and providing these scientists with ongoing training. A key role is played by the Helmholtz Management Academy and the Helmholtz mentoring programmes. In addition, under an alumni concept titled "Helmholtz & Friends", the association is fostering long-term ties among academy participants and laying the foundation for a network of current and former Helmholtz leaders.

Technology transfer creates added value and innovation

In 2013 the Helmholtz Association further expanded its technology transfer activities. In consultation with its member centres, it drew up a key-issues paper on the strategic development of technology transfer processes. Adopted by the Members' Assembly in April 2014, this paper contains a package of measures that will unlock even greater commercialisation potential in the future – e.g. through incentives and the promotion of an innovation-friendly culture. Previous instruments remain in place, including the "Shared Services" pilot project, which aims to professionalise and enable mutual support for the technology transfer offices at the individual centres, as well as the Helmholtz Validation Fund and Helmholtz Enterprise funding programmes.

The Validation Fund, founded in 2011, has so far selected a total of 15 projects to develop promising technologies to the point where they can be marketed. In a few cases this has already been achieved. License income from one Validation project at the DLR – running into millions of euros – made a significant contribution to the association's overall income from licenses and options in 2013. An external evaluation of the Validation Fund in June 2014 confirmed the success and professional implementation of the concept and recommended its continuance.

The second funding instrument, the Helmholtz Enterprise, is also contributing to the gratifying results in the area of technology transfer. In 2013 there were 19 research spin-offs, a new record. Since 2005, 99 companies have been founded. During the same period, 83 projects received Helmholtz Enterprise funding and resulted in 57 research spin-offs. This means that more than half of all Helmholtz start-ups received Helmholtz Enterprise support.

In 2013, Innovation Days were held to foster an exchange of ideas between science and industry. The Helmholtz Association was once again the main organiser of this event from the four major non-university research organisations. A total of 250 experts from the research community, industry and finance attended in order to learn more about the best technologies and start-up ideas and to attend partnering meetings. The Helmholtz Association has also enhanced its Research Day format and held two of these open innovation events – one with Bayer AG, the other with Robert Bosch GmbH. Their goal is to showcase technologies at the Helmholtz centres and to identify common research projects.

THIRD ROUND OF PROGRAMME-ORIENTED FUNDING

Within the framework of programme-oriented funding, the Helmholtz Association reviews the strategic scientific focus of its research and the related core funding at five-year intervals. Research activities are organised into strategic programmes that in most cases cut across centres and are reviewed by renowned experts from around the world. In 2013 experts evaluated the programmes in three of the association's six research fields: Health, Earth and Environment, and Aeronautics, Space and Transport. This year reviews followed in the remaining three fields: Energy, Key Technologies and Structure of Matter.

For the third programme period, the review process was more clearly aligned with the association's mission and adapted to current needs. An important point is the strict separation of the strategic programmes and the operation of large-scale research facilities that are used primarily by external scientists, including the photon and neutron sources for materials research and research vessels. Life-cycle analysis and user management play an important role in evaluations of these large-scale facilities, but other factors are considered as well, including their overall scientific concept, previous performance and technical equipment. The reviews proceeded in an extremely positive manner and provided a number of highly valuable insights for future use. Based on the results, the centres will receive adequate funding to operate the positively evaluated facilities. The funding levels take expected price increases into account.

The most important question: Are we doing the right things – and are we doing them right?

The reviews of the research topics in the individual programmes focused on two questions: scientific quality and strategic relevance. The evaluation of scientific quality takes into account not only expertise and originality but also the innovative potential of new technologies and developments. The assessment of strategic relevance concentrates above all on the selection of topics, the coherent makeup and coordination of processes, content and expertise, as well as on programme management as a whole. In addition, programme evaluations consider the contributions made to the objectives of the Joint Initiative for Research and Innovation, including general collaborative culture and new models, particularly those with university partners. Other important issues are the contributions to training and supporting young scientists and to making findings available to industry and society. Finally, multidisciplinary activities make it possible to combine and coordinate contributions to the research focuses that cut across programmes and often span the association's research fields. These topics include big data, the bioeconomy, electric mobility and safety research. These multidisciplinary activities are of special importance to the Helmholtz Association because the major challenges of the future require comprehensive solutions and cannot be adequately tackled without inter- and transdisciplinary approaches.

The most important objective: Today we are good – tomorrow we are better!

A total of 17 programmes and 13 large-scale research facilities were reviewed. The evaluations took place between January and April 2014 as part of an international peer-review process involving 59 female and 163 male experts, mostly from foreign research organisations. The results have provided a foundation to formulate requirements and recommendations for the programmes and the participating centres. These recommendations cover content-related issues linked to the optimisation and study of research topics, as well as financial resources. The Helmholtz Senate monitors the development of research programmes and, in particular, the implementation of strategic recommendations.

The reviews confirmed all the programmes' outstanding scientific quality and performance, which in some cases is unique in the world. In the research field Energy, the experts welcomed the restructuring of the programmes. Five programmes, including two that are pursued jointly with the field of key technologies research, address topics especially important for the Energiewende, or energy transition. These topics include renewable energy, energy efficiency and storage, as well as related economic and social issues. The field of energy research plans to launch the cross-programme initiative "Energy System 2050" in order to pool the results of the individual programmes and strengthen collaboration. An additional critical focus for the overall system is research on nuclear fusion, which is expected to replace coal and gas as a base load energy source, as well as on nuclear safety.

Significant advances and internationally unique activities are also hallmarks of the research field Key Technologies. These activities include above all work on nanosystems, supercomputing and big data. The reviewers were particularly positive in their evaluation of a project that is bringing together the neurosciences and computing technologies to achieve a better understanding of the human brain (also a goal of the European Human Brain Project, to which there are close ties). This project is part of the research field's strategy of more closely connecting research on generic technologies with applications in life sciences for the benefit of a world with more than seven billion inhabitants. Important topics here are degenerative diseases, regenerative medicine and plant research. Finally, the reviewers welcomed the research field's strategy of broadening its activities and organising them around three pillars: information technology, materials science and life sciences.

The research field Structure of Matter will begin the new programme period with a new name – Matter – and a significantly changed programme structure. The evaluations confirmed the correctness of this repositioning, especially the pooling of research on particles smaller than atoms and the launch of an independent programme that will conduct technological research into the accelerators and detectors needed for large-scale experiments. Research into the structure of matter is closely associated with large-scale infrastructure, particularly with the photon, neutron and ion sources operated by the Helmholtz Association. Evaluations highlighted the uniqueness of these facilities and their integrated use at the association. They include not only the FLASH and BER systems, which are already in operation, but also the large-scale international facilities XFEL and FAIR, whose assembly will continue at the Helmholtz centres DESY and GSI during the programme period.

Multidisciplinary activities to meet the major challenges of society

Many research topics transcend the boundaries of the individual programmes. Bioenergy, for example, has a special significance within the context of renewable energies and also for a sustainable bioeconomy. Likewise, energy storage systems need to be seen in conjunction with both Germany's energy transition and the area of mobility in general. The evaluations provided confirmation for the Helmholtz Association's decision to combine programmes' contributions to research focuses that cut across programmes and research fields and to organise them into five multidisciplinary alliances and thirteen multidisciplinary themes. The interplay between the programmes and the multidisciplinary activities will be one of the challenges in the new programme period.

All in all, the reviews of the third programme period have produced very positive results and provided valuable support for the Helmholtz Association's efforts to focus its research. At the same time, they have produced a number of results that are important for further strategic planning and will make it possible to improve the programmes on an ongoing basis.

SCIENTIFIC PRIZES AND AWARDS

2014 ERWIN SCHRÖDINGER PRIZE

A single molecule can provide hope for millions: Matthias Tschöp, Brian Finan, Kerstin Stemmer (all Helmholtz Zentrum München) and Richard DiMarchi (Indiana University, USA) have combined two hormones formed in the digestive tract into a single molecule. This hormone combination could effectively lower blood sugar levels in patients suffering from obesity or type 2 diabetes. For their work the researchers received the 2014 Erwin Schrödinger Prize worth 50,000 euros.

www.helmholtz.de/en/schroedingerprize

Helmholtz President Jürgen Mlynek, Richard DiMarchi, Brian Finan, Federal Minister Johanna Wanka, Kerstin Stemmer and Matthias Tschöp. *Image: Marco Urban*

SCIENTIFIC PRIZES

Awards and prizes increase the visibility of the outstanding researchers working at the Helmholtz Association. The examples listed here show the achievements of scientists at different stages of their careers.

Alzheimer Research Award of the Hans and Ilse Breuer Foundation: Dieter Edbauer and Michael T. Heneka (DZNE); Curt Meyer Memorial Prize: Sandrine Sander (MDC); German Cancer Aid Award 2013: Hans-Georg Rammensee (DKTK); German Cancer Award 2014: Simone Fulda (DKTK); Dr. Paul Janssen Award for Biomedical Research: Emmanuelle Charpentier (HZI); Ernst Schering Prize 2014: Magdalena Götz (HMGU); European Research Council Advanced Grant: Magdalena Götz (HMGU), Thomas Willnow (MDC); European Research Council Consolidator Grant: Oliver Daumke (MDC), Dieter Edbauer (DZNE), Martin Elsner and Tillmann Lüders (HMGU), Jochen Küpper (DESY)

Gottfried Wilhelm Leibniz Prize 2014: Rainer Waser (Forschungszentrum Jülich); Göran Gustafsson Prize: Emmanuelle Charpentier (HZI); Kavli Prize for the Nanosciences: Stefan W. Hell (DKFZ); Kind Philipp Prize: Ina Oehme and David Jones (both DKFZ); Nernst Haber Bodenstein Award: Emad Flear Aziz (HZB); Prize of the Åland Foundation for the Future of the Baltic Sea: Hans von Storch (HZG); Young Investigator Grant of the Human Frontiers Science Program: Alexandros Vegiopoulos (DKFZ)

European Research Council Starting Grant: Guido Grosse (AWI), Erin Crystal Koos and Pavel Levkin (both KIT), Thomas Wolbers (DZNE); European Research Council Synergy Grant: Ralph Wolfgang Aßmann, Petra Marie-Luise Fromme (both DESY, together with Henry Nicholas Chapman and Franz Xaver Kärtner, both Hamburg University); Felix Burda Award: Ulrike Stein (MDC); Frontiers of Knowledge Award: Knut Urban (FZJ) and Maximilian Haider (KIT, together with H. Rose, Ulm University); Gay-Lussac Humboldt Research Award 2013: Oliver Eickelberg (HMGU)

RESEARCH FIELD ENERGY

PROFESSOR HOLGER HANSELKA
Vice-President of the Helmholtz Association,
Coordinator of the Research Field Energy,
Karlsruhe Institute of Technology

MISSION

Helmholtz scientists involved in the field of energy research are working to secure an economically, ecologically and socially sustainable supply of energy. They are examining conversion, distribution, storage and utilisation technologies and taking climatic and environmental impacts into account. One important goal is to replace fossil and nuclear fuels with climate-neutral energy sources and help to establish a sustainable energy system. For this purpose they are seeking to determine the potential of renewables such as solar, biomass and geothermal energy. Researchers are also working to increase the efficiency of conventional power plants. Finally, the Helmholtz Association is pursuing the long-term goal of developing nuclear fusion as a new energy source, and it boasts outstanding expertise in the area of nuclear safety and final repository research.

PROGRAMME STRUCTURE IN THE CURRENT FUNDING PERIOD

Eight Helmholtz centres are currently working in the field of energy research, which is divided into five research programmes:

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

Interdisciplinary working groups implement the programmes in international collaborations.

OUTLOOK

The *Energiewende*, or energy transition, is one of the greatest challenges facing present and future generations. In its 6th Energy Research Programme, the German government is concentrating on renewable energy, energy efficiency, energy storage and grid technologies. The Helmholtz Association emphatically supports this strategy and is making a significant contribution to its implementation by pooling its expertise and experience in various programmes. In addition, the association is closing research gaps and carrying out basic and application-oriented research. It is supplementing its technological research with socioeconomic studies in order to ensure that all social, economic and political aspects are included in its overall goal of improving the energy system.

PROGRAMMES IN THE COMING FUNDING PERIOD 2015–2019

Energy Efficiency, Materials and Resources

The objective of the energy transition is to cut primary energy consumption in half and achieve an 80 to 95 per cent reduction in greenhouse gas emissions by 2050. For this purpose, process chains, resources, materials development, process engineering and energy conversion processes will be studied, interlinked and optimised. In addition, the flexibility required to restructure the energy supply will be improved with respect to fuel types, energy provision and infrastructure.

Renewable Energies

Renewable sources will supply the lion's share of energy in the future. The goal is to exploit the various primary energy sources (such as solar, wind, biomass and geothermal) in an efficient, cost-effective manner and to develop optimal

Karlsruhe Institute of Technology (KIT)

Using the bioliq pilot plant, KIT researchers have produced their first batch of gasoline from straw and other organic residues. *Image: M.Torge/KIT*

PILOT PLANT PRODUCES BIOGASOLINE

In the multistage process at KIT's bioliq plant, synthetic gasoline is made from straw and other biological residues. The synthesis stage has now been successfully implemented and fuel has been produced for the very first time. This means the plant is now fully assembled. The last step will be to test the complete process chain and optimise it for large-scale industrial use.

The entire bioliq ("biomass to liquid") process consists of four stages. In the first, dry residual biomass such as straw that accumulates in fields and has a low energy content is converted into a substance similar to crude oil with a high energy density. Flash pyrolysis – the thermal decomposition of organic matter – forms the basis of this process. The crude-oil-like substance can be transported over long distances in a cost-effective manner and centrally processed. In a high-pressure entrained flow gasifier, it is converted into a tar-free syngas at temperatures above 1,200 °C and pressures of up to 80 bar. The syngas consists primarily of carbon monoxide and hydrogen. In the subsequent hot gas purification process, impurities such as particulate matter and chlorine and nitrogen compounds are removed. Finally, in the synthesis stage, the purified gas is formed into a customised, high-quality fuel.

In terms of its design, the plant has been specially adapted to the properties of the CO_2-rich syngas that is produced by biological residues. Using the pilot plant, researchers can test innovations directly on an industrial scale to ensure that findings can be commercialised more quickly.

The construction of the pilot plant on KIT's northern campus was funded by the German federal government, the state of Baden-Württemberg and the European Union. Several industrial partners are involved in the bioliq plant along with numerous institutes and service units at KIT.

Further examples from this research field

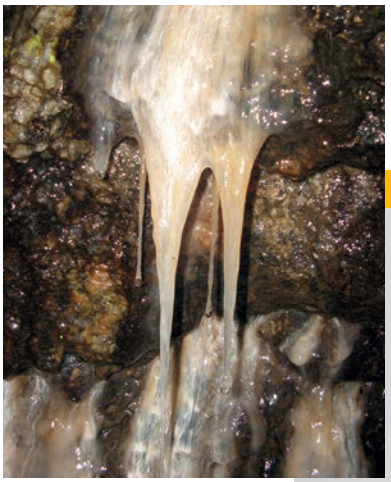
technologies for centralised and decentralised applications. The strategic research themes in this programme involve scientific issues that require highly complex, long-term investigations utilising the large-scale facilities of the participating Helmholtz centres.

Storage and Cross-Linked Infrastructures

The energy transition has made it necessary to develop cost-efficient energy storage systems and infrastructure for energy transmission and distribution. In order to ensure a successful transition to an energy supply based primarily on volatile renewable sources, adequate energy storage solutions need to be established and consequently implemented in an optimised energy system. Research in this programme is aiming to achieve prompt applications, eco-friendly production, high efficiency and reliable systems integration.

Future Information Technology

Information and communication technology is becoming



Bacterial biofilms could play an important role in increasing the safety of final repositories for radioactive substances. *Image: HZDR*

Helmholtz-Zentrum Dresden-Rossendorf (HZDR)

MICROORGANISMS FILTER URANIUM OUT OF GROUNDWATER

In a planned Finnish repository for highly radioactive waste from nuclear power plants, HZDR researchers have discovered bacteria that can convert dissolved uranium into needle-like crystals. As their investigations show, these crystals consist of a uranyl phosphate mineral that forms in the process. In this way, the microorganisms filter radioactive material out of water and bind it. This means they can also reduce the bioavailability of uranium – and the probability that it will pass into the human food chain.

The Leipzig foam tester.
Image: André Künzelmann/UFZ

Helmholtz Centre for Environmental Research – UFZ

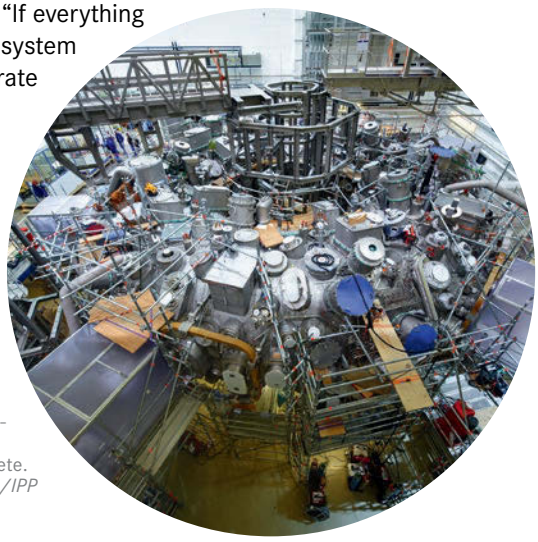
TRACKING FOAM

Biogas plays an important role as a renewable energy source – there are now around 7,700 biogas plants in Germany. Effective plant operation is necessary for optimal output, and disruptions such as uncontrolled foaming – the consequences of which range from reduced output to damaged containers – must be avoided. UFZ researchers have developed the "Leipzig foam tester" as a counter-measure. In 2014 this device was awarded the IQ Innovation Prize of the City of Leipzig.

Max Planck Institute for Plasma Physics (IPP)

WENDELSTEIN 7-X FUSION DEVICE SOON TO GO INTO OPERATION

After years of planning, production and assembly, final preparations began in May 2014 for the operation of Wendelstein 7-X, the world's largest stellarator fusion device. The plant's technical systems are currently being tested in a step-by-step process: the vacuum, the cooling system, the specially shaped superconducting coils and the magnetic field they generate. "If everything works properly, the system will be able to generate the first plasma in about a year," says project manager Thomas Klinger. The goal is to demonstrate the viability of a stellarator power plant.



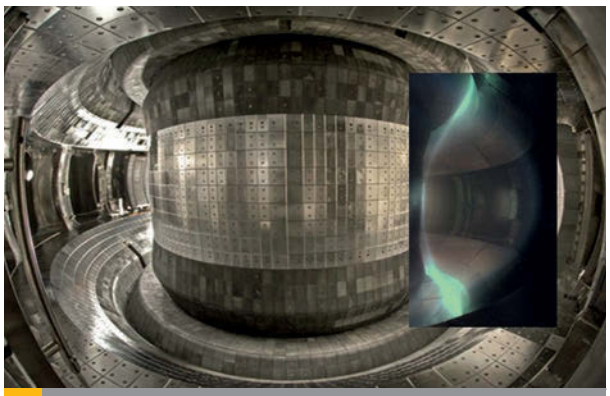
A glimpse into the experiment room: the main assembly stage is complete. *Image: Bernhard Ludewig/IPP*

PROGRAMMES IN THE COMING FUNDING PERIOD 2015–2019

increasingly powerful and energy-intensive. New approaches are needed to reduce energy use. In collaboration with the field of key technologies research, this programme will examine the fundamentals of the new solid state based technologies and strategies for energy-efficient data storage and processing. It will also address the basic problems of material systems in the areas of energy production, conversion, and storage.

Technology, Innovation and Society

The success of scientific innovations not only depends on their scientific and technical quality, but is also governed by economic, ecological, political, cultural and ethical factors. In cooperation with the field of key technologies research, this programme will combine energy system analysis, technology impact assessment, sustainability research and risk and innovation research in order to study these complex issues from an interdisciplinary perspective.



The interior of the Chinese tokamak fusion reactor EAST with high-energy plasma (small image). *Image: Institute of Plasma Physics/Chinese Academy of Sciences*

Forschungszentrum Jülich

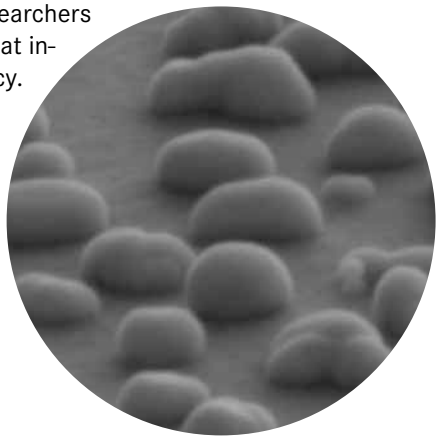
FUSION RESEARCHERS CONTROL PLASMA FOR RECORD TIME

Nuclear fusion reproduces the processes taking place inside the sun. One of the most important questions in developing this technology is how the unstable, difficult-to-control fusion reaction can be sustained for a prolonged period of time. A team led by Jülich fusion researcher Yunfeng Liang has now developed a new method for further confining the uncontrolled plasma discharges. Using radio waves, they were able to sustain a high-energy plasma for a record 30 seconds at the experimental fusion reactor EAST in China.

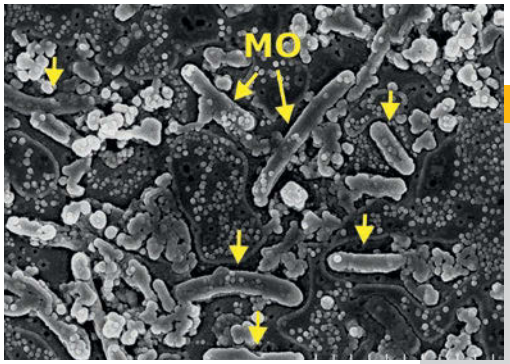
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)

EVEN THINNER SOLAR CELLS THROUGH THE USE OF NANOPARTICLES

Nanostructures could be used to direct more light into the active layer of solar cells, thereby increasing their efficiency. Martina Schmid (HZB and the FU Berlin) has measured how irregularly distributed silver particles change the absorption of light. She showed that nanoparticles interact via their electromagnetic near-fields, creating local hot spots where the light is most highly concentrated. Her findings will help researchers design nanostructures that increase solar cell efficiency.



As this scanning electron micrograph shows, the silver nanoparticles are irregularly shaped and randomly distributed on the surface. *Image: HZB*



Scanning electron micrograph of a filter sample with microorganisms (MO) and mineral precipitation. *Image: M. Kasina/GFZ*

Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences

A BYPASS SYSTEM TO STUDY MICROBIAL METABOLIC PROCESSES IN GEOTHERMAL SYSTEMS

In collaboration with industry partners, scientists from the GFZ have developed a mobile bypass system for geothermal plants. With the help of the bypass, researchers can carry out on-site investigations of the effects of microbial metabolic processes on precipitation and corrosion at different temperatures. In terms of the size and shape of the material samples, the system can be adapted to site-specific conditions and can be used in different areas of a plant. The goal is to develop effective measures to mitigate microbiologically influenced plant disturbances.

Nuclear Waste Management and Safety, as well as Radiation Research

The German Bundestag has decided to terminate the production of nuclear energy and shut down the last German nuclear power plant by 2022. A new federal law will redefine the procedure for selecting the location of a final repository for highly radioactive waste in Germany. This Helmholtz programme will be an integral part of forward-looking national research and address the challenges posed by the new set of conditions.

Nuclear Fusion

As a nearly inexhaustible, safe and CO_2-free source of energy, fusion has the potential to make a significant contribution to meeting the world's growing energy needs by mid-century. The goal of this programme is to provide a foundation for the development and construction of a fusion power plant. Two central projects that will continue to dominate fusion research over the next 20 to 30 years are ITER and Wendelstein 7-X.

RESEARCH FIELD EARTH AND ENVIRONMENT

PROFESSOR GEORG TEUTSCH
Vice-President of the Helmholtz Association,
Coordinator of the Research Field Earth and Environment,
Helmholtz Centre for Environmental Research – UFZ

MISSION

The Helmholtz scientists involved in the research field Earth and Environment examine the basic functions of the Earth system and the interactions between society and nature. They focus on expanding and interconnecting long-term observation systems, improving predictions and making findings quickly available to society. They formulate knowledge-based policy recommendations on how the Earth's resources can be used in a sustainable fashion without destroying the foundations of life. For example, REKLIM, a Helmholtz climate initiative, is bringing together the expertise of nine Helmholtz centres in order to improve regional and global climate models. Another important goal is to establish and operate infrastructure and facilities such as the HALO research aircraft and the TERENO network, for which terrestrial observatories have been set up in four selected regions in Germany. Within the scope of the COSYNA project, a long-term observation system is created for the German North Sea and later extended to Arctic coastal waters.

PROGRAMME STRUCTURE IN THE CURRENT FUNDING PERIOD

Eight Helmholtz centres are currently participating in the research field Earth and Environment. Work is carried out in five programmes:

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

OUTLOOK

To meet the current challenges, the research field Earth and Environment will continue to pool the capacities of the participating centres within shared research portfolios. This strategy is leading to new alliances and facilitating the expansion of Earth observation and knowledge systems as well as integrated modelling approaches. The interdisciplinary portfolio project "Earth System Knowledge Platform – Observation, Information and Transfer" is integrating the knowledge acquired by all of the centres in this research field as well as by their partners. Its aim is to help society to cope with the complex challenges brought about by changes in the Earth system.

PROGRAMMES IN THE CURRENT FUNDING PERIOD 2014–2018

Geosystem: The Changing Earth

This programme analyses processes in the geosphere and their interaction with the hydrosphere, atmosphere and biosphere. Goals include monitoring, modelling, understanding and evaluating key processes, creating solutions and strategies to prevent disasters, and developing geotechnologies for the utilisation of underground space. To attain these goals the programme uses satellite missions, airborne systems, global geophysical and geodetic networks, regional observatories, deep drilling rigs, mobile instrument pools and analytical and experimental facilities.

Marine, Coastal and Polar Systems

This programme concentrates on a variety of issues: changes in the Arctic and Antarctic; the interaction between these

Helmholtz Centre for Environmental Research – UFZ

The facility, covering an area of almost seven hectares (ten football fields), contains ten experimental fields with five plots each. The plots can be planted with various species and subjected to the different climatic conditions predicted for central Germany. *Image: André Künzelmann/UFZ*

SIMULATING THE FUTURE

What will climate change bring? Scientists at the Global Change Experimental Facility (GCEF) are attempting to answer this question. The research station is home to one of the largest long-term experiments of its kind in the world, set to run for at least 15 years. The findings will help environmentalists, conservationists and farmers to better adapt to climate change. Scientists expect that temperatures will be hotter in central Germany by the end of the century and that there will also be less rainfall, especially in the summer months. But what do these changes mean for ecological processes? In order to accurately simulate such scenarios, researchers covered normal agricultural fields in Bad Lauchstädt (Halle/Saale) with steel frames fitted with closable roofs and side walls. As in a greenhouse, temperatures inside these enclosures can be increased by up to three degrees at night and the first ground frost can be delayed by several weeks. Researchers can also keep rain off the fields or add additional water via a sprinkler system.

"The GCEF is certainly not the first experiment to simulate climate change, but it is unique in the sense that it operates on a larger temporal and spatial scale," says Stefan Klotz, head of the Biocoenology Department at UFZ. Each of the 50 plots measures 16 by 24 metres. For each group of five plots in which climate change is simulated for conventional agriculture, organic farming, intensive grassland farming, extensive grassland farming based on mowing, and extensive grassland farming based on grazing, identical groups have been set up without changed temperatures or precipitation levels for purposes of comparison. Much of the information that the GCEF will supply over the next few years will be measured and processed by a self-organising wireless sensor network developed at UFZ. A kind of WLAN network, this system contains many small stations that will measure the humidity and temperature of both the air and soil, as well as radiation intensity. The components that visitors can see form only part of this state-of-the-art technology, most of which is buried underground or is transmitted as data through the air.

Further examples from this research field »

changes and the global climate and polar ecosystems; vulnerable coasts and shelf seas; the polar perspective of Earth system analysis; and the interplay between science and society. It provides insights into climate variability and regional climate change, sea-level change as an element of risk analysis within the Earth system, and the transformation of coastal and polar ecosystems. The programme is also providing the scientific foundation to assess the social and economic consequences of climate change in the places where we live. Work in the field "Interaction between Science and Society" is examining how research findings can be effectively integrated into information and decision-making processes in society as a whole.

Oceans

Oceans cover 70 per cent of the Earth's surface. Deep oceans, in particular, are difficult to access and remain largely unexplored. This interdisciplinary programme will

This robot, operated by KIT researchers, automatically measures nitrous oxide emissions from the soil. *Image: E. Díaz-Pines*

Karlsruhe Institute of Technology (KIT)

CONVERSION OF HARMFUL NITROUS OXIDE UNDERESTIMATED

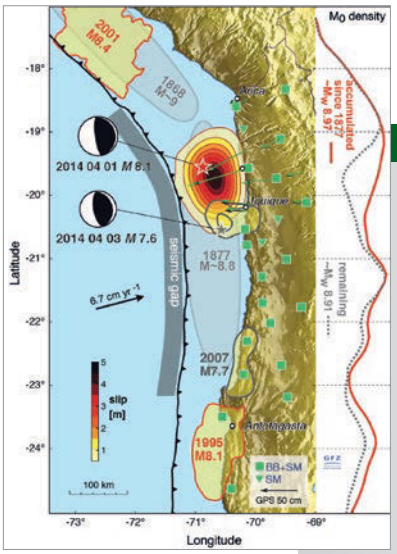
As a greenhouse gas, nitrous oxide (N_2O) contributes to climate change and damages the ozone layer. The greenhouse effect of an N_2O molecule in the atmosphere is about 300 times greater than that of a carbon dioxide molecule. The use of mineral fertilizers is increasing the amount of nitrous oxide in the soil. KIT scientists have now determined that if harmful N_2O is reduced to harmless molecular nitrogen (N_2), only about one-fifth of the nitrous oxide produced is released into the atmosphere.

Alfred Wegener Institute Helmholtz-Center for Polar and Marine Research (AWI)

NEW SPECIES IN THE ARCTIC OCEAN

Over the last few years, amphipods from the North Atlantic have been reproducing in the Arctic Ocean. Researchers at the long-term HAUSGARTEN observatory in the Fram Strait have found evidence of this species' migration. Ten years ago, it was above all cold-loving amphipods from the Arctic that were caught in their sediment traps. Then, in 2005, AWI researchers discovered the first specimens of the Atlantic species *Themisto compressa*. The animals had reached the Fram Strait from the Atlantic waters in the south, which were warming, and proved to be highly adaptable.

A sample from the specimen container: a female Atlantic amphipod with bulging brood pouch. *Image: A. Kraft/AWI*



The Iquique earthquake broke a central piece of the seismic gap that had existed for over 130 years. Green symbols show the stations of the Integrated Plate Boundary Observatory Chile; green arrows indicate measured surface displacement. *Image: B. Schurr/GFZ*

Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences

SERIES OF FORESHOCKS CONTROLS COURSE OF EARTHQUAKE

A protracted series of foreshocks played a major role in steering the development of the rupture process during the major earthquake that struck Iquique in northern Chile in April 2014. The series of foreshocks occurred over a nine-month period and culminated in a magnitude 6.7 event two weeks before the magnitude 8.1 main quake. An international research team led by GFZ scientists determined that the Iquique earthquake occurred in the area of the last seismic gap before the Chilean coast. In several clusters, the foreshocks first broke the edge of the central section that then was ruptured by the main quake.

PROGRAMMES IN THE CURRENT FUNDING PERIOD 2014–2018

examine the physical, chemical, biological and geological processes in oceans as well as the interactions between these processes and the ocean floor and the atmosphere. It will focus on the role of the ocean in climate change, human impact on marine ecosystems, the possible use of the oceans' biological, mineral and energy resources, and the potential risks of geodynamic processes in the oceans and deep seas.

Atmosphere and Climate

The goal of this programme is to better understand the function of the atmosphere within the climate system. To this end scientists are carrying out extensive measurements of atmospheric parameters, performing laboratory tests and creating numerical models of processes that play an important role in the atmosphere. Focuses include high-resolution satellite measurements of tropospheric trace gases as well as studies of the role of the middle

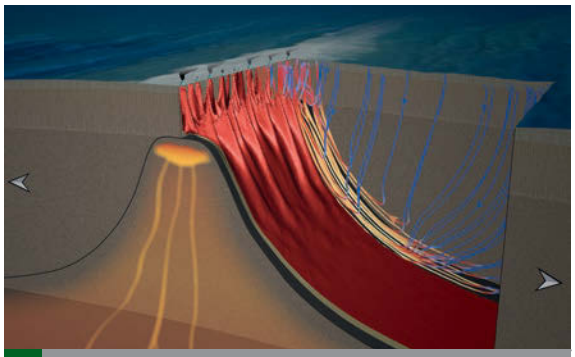
Ragweed is the bane of allergy sufferers. *Image: U. Frank/ Helmholtz Zentrum München*

Helmholtz Zentrum München – German Research Center for Environmental Health

CLIMATE CHANGE AFFECTS THE ALLERGENIC POTENTIAL OF POLLEN

Ragweed is a plant species whose pollen can cause particularly severe allergic reactions and asthma. Scientists from the Helmholtz Zentrum München are studying how climate change affects the allergenicity of plants. They have already found elevated stress levels in plants exposed to increased amounts of ozone, which may result in more aggressive pollen, even if the number and size of pollen grains remain the same. The researchers also intend to take a closer look at the effects of drought as well as the influences of higher levels of CO_2, NO_2, particulate matter and UV-B radiation.

Simulation of the supply routes to hydrothermal vents on mid-ocean ridges. The arrows indicate the direction in which the tectonic plates are moving. *Image: J. Hasenclever/GEOMAR*



GEOMAR Helmholtz Centre for Ocean Research Kiel

HOW PRODUCTIVE ARE DEEP-SEA ORE FACTORIES?

Hydrothermal vents in the deep ocean, also called black smokers, are fascinating geological formations. They are home to unique ecosystems and have the potential to supply raw materials in the future. They are driven by volcanic "power plants" in the ocean floor and release an enormous amount of energy. With the help of computer simulations, GEOMAR researchers have now succeeded in understanding the underground supply routes leading to black smokers.

Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)

SHIPPING EMISSIONS ON THE NORTH SEA

Ships release large quantities of air pollutants such as nitrogen oxides, sulphur oxides and aerosol particles. At Helmholtz-Zentrum Geesthacht, researchers led by Volker Matthias are using a chemistry transport model to investigate the effects of shipping emissions on air quality in the North Sea area. They have calculated current emissions on the basis of ship movement data. Their simulations show that ships make a significant contribution to the concentration of pollutants at the coast and far inland. By 2030, nitrogen oxides emitted by ships could increase by 25 per cent.

The combustion of fuel oil on ships produces toxic emissions. *Image: iStockphoto*

atmosphere within the climate system, the variability of biogenic emissions and the use of atmospheric water isotopes for a better understanding of the water cycle.

Terrestrial Environment

The goal of this programme is to preserve the natural foundations of human life and health. It is concerned with the effects of global and climate change on terrestrial environmental systems and formulates strategies for managing sustainable social and economic development. Research ranges from the micro to the global level, often emphasising selected regions and landscapes. It is here that environmental problems become directly visible and management options can be identified. Topics include land use, biodiversity, ecosystem services, plant growth, water resource management, the assessment and reduction of risks associated with chemicals in the environment, as well as observation platforms and integrated modelling.

RESEARCH FIELD HEALTH

PROFESSOR GÜNTHER WESS
Vice-President of the Helmholtz Association,
Coordinator of the Research Field Health,
Helmholtz Zentrum München – German Research Center for Environmental Health

MISSION

The scientists involved in health research at the Helmholtz Association are studying the causes and development of major common diseases such as cancer, cardiovascular and metabolic diseases, pulmonary illness, disorders of the nervous system, allergies and infectious disease. Building on a strong foundation of basic research, they aim to develop evidence-based methods for the prevention, diagnosis, early detection and individualised treatment of common diseases. Research into complex and often chronic illnesses requires interdisciplinary approaches, which the Helmholtz centres are implementing in cooperation with partners from medical schools, other research organisations and industry. In addition, as a partner to the German Centres of Health Research, which were founded by the Federal Ministry of Education and Research, the Helmholtz Association is working to make research findings more rapidly available for clinical applications and individualised medicine.

PROMGRAMME STRUCTURE IN THE CURRENT FUNDING PERIOD

Eight Helmholtz centres are collaborating in the field of health research. In the current programme period, they bundle their efforts in the following five programmes:

- Cancer Research
- Cardiovascular and Metabolic Diseases
- Infection Research
- Disorders of the Nervous System
- Genetic and Environmental Influences on Common Diseases

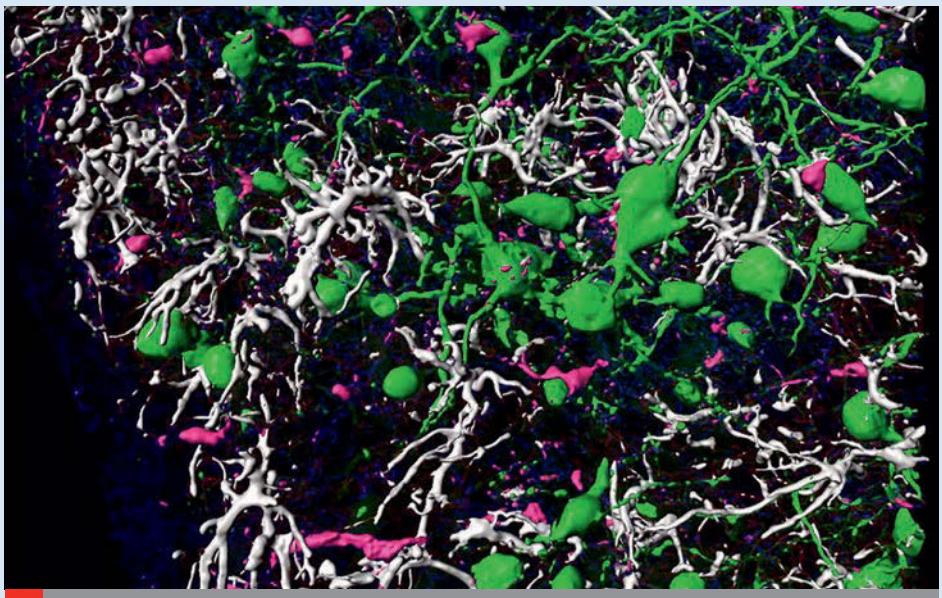
OUTLOOK

The long-term goal of Helmholtz health research is to improve medical care and quality of life for the population into old age. For this reason the Helmholtz health centres regularly check whether additional diseases such as mental disorders should be added to the portfolio, and they are also taking steps to integrate prevention research into their research programmes. The “National Cohort” health study, which the association has initiated, will continue to lay the foundation for new approaches to the assessment of individual risk factors and the development of personalised prevention strategies. In all these activities, the ongoing discourse between scientists and physicians will play a vital role in enabling a quick translation of research findings into clinical practice.

PROGRAMMES IN THE CURRENT FUNDING PERIOD 2014–2018

Cancer Research

The goal of this programme is to significantly improve the prevention, early detection, diagnosis and treatment of cancer. To this end it is developing new diagnostic and individualised therapeutic procedures on the basis of molecular, cell-biological, immunological and radio-physical findings and technologies. It will continue to translate basic research findings into clinical applications together with strategic partners. In this area a key role is played by the National Centre for Tumour Diseases (NCT) and the nationally active German Consortium for Translational Cancer Research (DKTK).



3D reconstruction of nerve and glial cells in the hypothalamus – the brain region that regulates blood sugar levels in combination with messenger substances. *Image: Chun-Xia Yi/Helmholtz Zentrum München*

Helmholtz Zentrum München – German Research Center for Environmental Health

TRICKING THE BRAIN – HORMONAL THERAPEUTIC APPROACHES TO DIABETES

"We can influence metabolism using hormones that have a direct impact on the digestive organs – and also on the brain," says Matthias Tschöp, scientific director of the Helmholtz Diabetes Center at the Helmholtz Zentrum München. Via a complex network of signalling molecules, the stomach, intestine and pancreas communicate directly with the brain – and vice versa. The disruption of this interaction in patients suffering from diabetes and obesity is now being targeted by novel therapeutic approaches. Surgical treatments of obesity, such as gastric bypass, are able to improve blood sugar levels in patients even before they lose weight. The Munich-based scientists achieved the same effect by placing a tube or sleeve in part of the small intestine to inhibit its function instead of performing a complex operation. The advantage of this method is that it is much less invasive and can be reversed.

These interventions in the gastrointestinal tract alter the body's hormonal control system. Tschöp and his team found that sensitivity to the intestinal hormone GLP-1 (glucagon-like peptide 1) played a key role in the effectiveness of the surgical procedure. In the future, a corresponding hormone test could make it possible to individually tailor surgical methods.

The positive effect that the operations had on fat and sugar metabolism can be explained by the altered concentrations and effects of metabolic hormones such as the insulin-stimulating GLP-1 and GIP (gastric inhibitory peptide). This suggests that physicians could administer such hormones to patients in order to mimic these positive effects – or, as Tschöp puts it, "to trick the brain into believing that an operation has taken place". GLP-1 based drugs have long been used to treat diabetes, but Tschöp and his team wanted to maximise their impact. They have managed to create a multifunctional combination of hormones that brings together the positive properties of several hormones in a single molecule. With it they have been able to improve blood sugar levels and reduce body weight in animals. "We know that the messenger substances have complex functions," says Tschöp. "Our goal is to crack their code so that we can develop new therapies for common diseases such as diabetes and obesity."

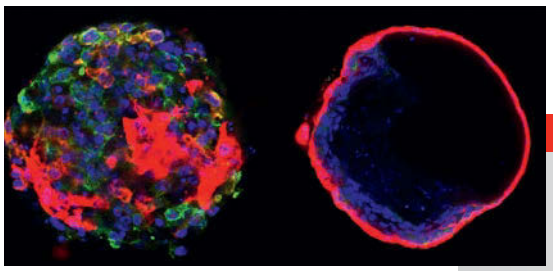
Further examples from this research field »

Cardiovascular and Metabolic Diseases

The aim of this programme is to study the causes and pathophysiological aspects of cardiovascular disease at the cellular, genetic and epigenetic levels and to investigate their interaction with environmental causes. The findings will be used to develop new diagnostic, preventive and therapeutic strategies. The programme takes a translational approach, transforming new results into clinical applications as quickly as possible.

Infection Research

This programme concentrates on the molecular mechanisms responsible for the development and course of infectious diseases. Knowledge of the interactions between hosts and pathogens is providing a foundation for the elaboration of new prevention and treatment strategies. Focuses include the study of newly emerging infectious diseases, the identification of new drugs to overcome pathogen resistance, the relationship between infection and age, as well as diagnostics



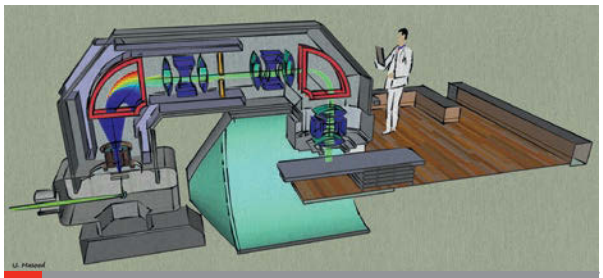
Basal breast cancer in a 3D organoid culture (left) and after treatment with an inhibitor of the Met receptor (right). *Image: G. Valenti, J. Holland/MDC*

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

POINTS OF ATTACK IDENTIFIED FOR TREATMENT OF BREAST CANCER

Breast cancer is the most common form of cancer in women. For patients with hormone-negative basal breast cancer, the prognosis is bleak. Because this cancer is not controlled by hormones, anti-hormone therapy is ineffective. Together with their colleagues, Jane Holland and Walter Birchmeier have developed a model for this type of breast cancer based on two mutated and activated signalling pathways (ß-catenin/Wnt and HGF/Met). Their research has revealed new points of attack for therapy. Combinatory therapies that target signalling molecules and receptors have been particularly successful in mice and could prove useful in human patients.

Design of a small proton therapy facility. *Image: Umar Masood*



Helmholtz-Zentrum Dresden-Rossendorf (HZDR)

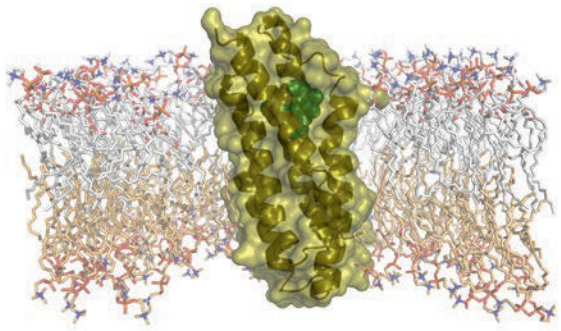
COMPACT PROTON THERAPY FOR CANCER

In a conceptual design study, researchers from the HZDR and OncoRay have reduced the size of a proton therapy facility by 50 per cent. To do so they replaced the facility's ring accelerator with a laser accelerator that requires only a few millimetres to accelerate particles. In order to guide the proton beam from the accelerator to the patient, they developed a compact guidance system that uses pulsed magnets and takes up less space than normally required for this component. The design would significantly reduce costs. Proton therapy is a very precise way of fighting cancer.

German Center for Neurodegenerative Diseases (DZNE)

STRUCTURE OF CHOLESTEROL TRANSPORTER DECODED

Together with Max Planck researchers, scientists at the DZNE have solved the atomic structure of the molecular transporter TSPO. This transporter introduces cholesterol into the cell's power plants, the mitochondria, and also serves as a docking site for diagnostic markers and various medications such as Valium. The detailed knowledge of its three-dimensional shape is opening up new possibilities for diagnosis and treatment.



The cholesterol transporter TSPO serves as a docking site for important diagnostic markers and various medications such as Valium. *Image: L. Jaremko, M. Jaremko, M. Zweckstetter/DZNE, Max Planck Institute for Biophysical Chemistry and UMG*

PROGRAMMES IN THE CURRENT FUNDING PERIOD 2014–2018

for personalised therapies. An important role is played by post-infection diseases such as cancer, metabolic dysfunction, neurodegeneration and chronic infections.

Disorders of the Nervous System

The goal of this programme is to study the causes of nervous system disorders and create more efficient methods for their prevention, diagnosis, treatment and care. Research is focused above all on major neurodegenerative diseases such as Alzheimer's and Parkinson's, but also addresses less common disorders such as Huntington's chorea, amyotrophic lateral sclerosis and prion diseases. In addition, scientists are studying disorders that may in part be based on similar pathological processes or that are often associated with classical neurodegenerative diseases. In order to develop better strategies for diagnosis, treatment and care,

Pseudomonas aeruginosa.
Image: M. Rohde/HZI

Helmholtz Centre for Infection Research (HZI)

COMBATING HOSPITAL BACTERIA WHILE AVOIDING THE DEVELOPMENT OF RESISTANCE

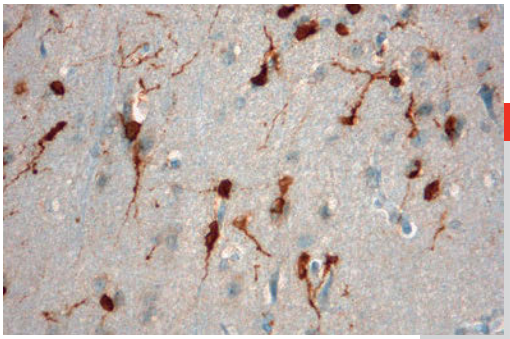
Resistance against antibiotics in hospital bacteria such as *Pseudomonas aeruginosa* is a common problem. Using targeted drug design, scientists at the Helmholtz Institute for Pharmaceutical Research Saarland (a branch of the Helmholtz Centre for Infection Research) have developed a substance to fight Pseudomonas infections while also avoiding the formation of resistance. The substance works by disrupting bacterial communication and keeping bacteria from producing toxins but without interfering with any of their vital processes.

GSI Helmholtz Centre for Heavy Ion Research

FINDING AND TREATING TUMOURS WITH PROTONS

Can a tumour be diagnosed and treated at the same time? This idea could soon become a reality. In a collaborative experiment conducted by the GSI Helmholtz Centre for Heavy Ion Research, the Technical University of Darmstadt and the Los Alamos National Laboratory in the United States, researchers have shown that the beams of fast protons could do the trick. Scientists call this combination of therapy and diagnostics "theranostics".

The existing treatment with carbon ions, which was developed at GSI, could be improved by proton theranostics. *Image: Achim Zschau/GSI*



The mutated tumour cells of a glioma are stained brown. The altered protein is found in the cytoplasm and the cell extensions. Cell nuclei are blue. *Image: DKFZ*

German Cancer Research Center (DKFZ)

INITIAL SUCCESS WITH VACCINES AGAINST BRAIN TUMOURS

Tumour vaccines can help the body in its fight against cancer. Due to gene mutations in tumour cells, they often differ from healthy cells. These mutations result in altered proteins that immune cells can recognise. Scientists led by Michael Platten from the DKFZ and Heidelberg University Hospital have developed a vaccine that triggers an immune response to a mutated protein in brain tumours and thus stops tumour growth in mice. The safety of the vaccine will now be examined in a clinical trial.

it is necessary to learn more about disease mechanisms and the brain's response to a disease.

Genetic and Environmental Influences on Common Diseases

This programme focuses on the major common diseases of diabetes, pulmonary illness and allergies. Like cardiovascular disease, cancer and disorders of the nervous system, these diseases have diverse causes and result from the interplay between genetics, environmental factors and personal lifestyles. Due to changing living conditions and longer life expectancies, they are becoming increasingly prevalent. This programme deals with the influence of genes and environmental factors on human health. An important goal is to clarify the interactions between the organism and environmental factors in order to develop strategies and procedures for the personalised prevention, early detection, diagnosis and treatment of chronic diseases.

RESEARCH FIELD AERONAUTICS, SPACE AND TRANSPORT

PROFESSOR JOHANN-DIETRICH WÖRNER
Vice-President of the Helmholtz Association,
Coordinator of the Research Field Aeronautics,
Space and Transport, German Aerospace Center

MISSION

The scientists involved in aeronautics, space and transport research address the major challenges facing our society in the fields of mobility, information systems, communication, resource management, the environment and security. They develop concepts and solutions and provide advice for policymakers. The German Aerospace Center (DLR) is Germany's national centre for aeronautics and aerospace research. On behalf of the German government and in its capacity as the German space agency, it is responsible for research within the framework of the national aerospace programme and for Germany's contribution to the European Space Agency (ESA). The Helmholtz DLR@UNI Alliance provides a framework for content-based partnerships between universities and selected DLR facilities throughout Germany. The DLR also works closely with other Helmholtz research centres, particularly in the research fields Energy and Earth and Environment, and collaborates with the private sector on a project basis.

PROGRAMME STRUCTURE IN THE CURRENT FUNDING PERIOD

The German Aerospace Center (DLR) is the only Helmholtz centre in the field of aeronautics, space and transport research. Its scientists conduct research and collaborate in the following three programmes:

- Aeronautics
- Space
- Transport

OUTLOOK

In addition to the ever-evolving study of the previous research topics, scientists will collaborate with industry on research projects devoted to aircraft simulation, next-generation rail-based vehicles and robot development. In mid-2011, the DLR established an internal maritime safety research group in order to pool and expand research at the various DLR institutes. The activities in this area will be supported by the positively evaluated portfolio proposal "R&D and Real-Time Services for Maritime Safety".

PROGRAMMES IN THE CURRENT FUNDING PERIOD 2014–2018

Aeronautics

The significant increase in air transport over recent decades is likely to continue. In Europe, policymakers, representatives of industry and scientists have already agreed on a common research agenda that establishes basic conditions for Helmholtz research. Its goals are an expansion of the capacity of the air transport system, greater cost-effectiveness on the developmental and operational levels, the reduction of aircraft noise and harmful emissions, the enhanced attractiveness of air travel for passengers, and higher safety standards. A key aspect of the research agenda is its holistic perspective. At the same time, the Helmholtz programme places a strong emphasis on application-oriented research.

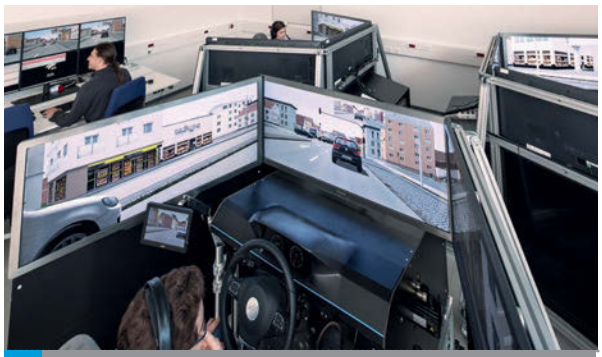
Alexander Gerst working on the BASS combustion experiment. *Image: NASA: 2Explore*

German Aerospace Center (DLR)

BLUE DOT: ALEXANDER GERST'S MISSION ON THE ISS

ESA astronaut Alexander Gerst, who has been living and working on board the International Space Station (ISS) since 28 May 2014, has been charged with carrying out one hundred experiments in a variety of fields, from material physics and space medicine to biology. A total of 25 of these experiments will be conducted under the guidance of German scientists or with the participation of German industry. Gerst's work is being supervised by the German Space Operations Center, operated by the DLR in Oberpfaffenhofen, and by user control centres across Europe such as the DLR's MUSC facility in Cologne.

Cooperative driving in the MoSAIC simulator. *Image: DLR*



German Aerospace Center (DLR)

A CITY BECOMES A TRANSPORT LAB

An entire city, including all the routes that residents take in their everyday lives, has been transformed into a transport lab. In July 2014 the city of Braunschweig saw the launch of the DLR's Application Platform for Intelligent Mobility (AIM). With the help of this platform, transport researchers and companies can develop and test new driver assistance technologies and efficient traffic management systems. The platform includes a research intersection, a sample stretch of road, various traffic simulators and vehicles that can be used to observe driver behaviour.

German Aerospace Center (DLR)

NASA AND THE DLR: JOINT RESEARCH FLIGHTS USING BIOFUEL

On joint test flights the US aerospace agency NASA, the DLR and the Canadian National Research Council (NRC) have investigated the emissions from a biofuel-kerosene mixture and the effects of this mixture on the formation and properties of condensation trails. Four research aircraft were involved in the tests conducted on May 2014 in California for the ACCESS II project. Initial analyses have shown that the use of biofuels substantially reduces particulate and soot emissions while also lowering the gaseous and particulate emissions from sulphur compounds.

Researchers and research aircraft participating in the ACCESS II project. *Image: NASA*

Space

The goal of this programme is to develop new technologies for use in basic research, operational services and commercial applications. The programme is oriented towards the German government's space strategy and has been tasked with developing the required technological foundations for new space missions and the collection and analysis of data. Research topics include Earth observation, communication, navigation, space exploration, research under space conditions, space transport and space systems technology, including robotics.

Transport

Ensuring mobility in the future is a central challenge. For many years now, the capacity of transport systems for passengers and goods has been expanding. However, there is an ongoing conflict between the individual desire for unlimited mobility, on the one hand, and overburdened transport systems, the negative effects of traffic on people and the environment, and the high number of accident victims, on the other. The world requires modern transport systems for people and goods that are sustainable over the long term from an economic, ecological and social perspective.

RESEARCH FIELD KEY TECHNOLOGIES

PROFESSOR WOLFGANG MARQUARDT
Vice President of the Helmholtz Association,
Coordinator of the Research Field Key Technologies,
Forschungszentrum Jülich

MISSION

In the field of Key Technologies Helmholtz scientists develop technologies that contribute to the future viability of our society. The individual research programmes cover the spectrum from fundamental research to concrete applications, are based on transdisciplinary collaboration, and are able to draw on an excellent research infrastructure. The Helmholtz Association supports the high-tech strategy of the German government. It is setting the pace for innovation and the development of future technologies in order to secure Germany's leading position in these fields and to ensure its continuing viability as a location for business. Our research programmes take into account the recommendations of the Science and Industry Research Union, the vote of the Bioeconomy Research and Technology Council, as well as strategic considerations within the EU.

PROGRAMME STRUCTURE IN THE CURRENT FUNDING PERIOD

Three centers are involved in the research field Key Technologies. This field comprises seven programmes:

- Supercomputing
- Fundamentals of Future Information Technology
- NANOMICRO: Science, Technology, Systems
- Advanced Engineering Materials
- BioSoft: Macromolecular Systems and Biological Information Processing
- BioInterfaces: Molecular and Cellular Interactions at Functional Interfaces
- Technology, Innovation and Society (joint programme of the research fields Energy and Key Technologies)

OUTLOOK

Energy, health, mobility, safety and communications are all areas for which forward-looking technologies are being developed. We are continuing and strengthening existing programmes in the areas of materials science, the nanosciences, information and communications technology, and the life sciences. In addition, we are using new transdisciplinary structures to create the foundation for future technologies in the fields of medicine and the life sciences. New transdisciplinary topics include technology and medicine, the sustainability of the bioeconomy, structural and synthetic biology, along with simulation, data management and data analysis at the exascale level.

PROGRAMMES IN THE COMING FUNDING PERIOD 2015–2019

Supercomputing & Big Data

The aim of this programme is to provide instruments and infrastructures for high-performance computing. The constantly growing complexity of systems and processes investigated by scientists is reflected in the steadily growing demands on the systems and methods. In this context the storage and processing of huge quantities of data represents a particular challenge.

Future Information Technology

A central aim of this programme is to reduce the amount of energy required for the information processing and storage. Novel approaches shall help to reach current technological and physical limits of energy efficiency and to overcome this limits.

Rainer Waser has developed particularly small, economical data storage devices. *Image: Forschungszentrum Jülich*

DATA STORAGE OF THE FUTURE: ENERGY-EFFICIENT AND POWERFUL

The goal of developing computers, sensors and energy convertors that use very little energy could be achieved using so-called redox-based resistive memory cells, or ReRAM. Rainer Waser is researching and developing these miniscule, fast and energy-saving electronic components at Forschungszentrum Jülich and RWTH Aachen.

In conventional data storage devices, electrons are moved around and stored. However, it is difficult to "subdue" these elementary particles in order to ensure that the stored information is not lost over time. It is not only storage density and speed that are problematic – this form of data storage also requires a lot of energy. For this reason, scientists all over the world are working on nanoelectronic components that use charged atoms, or ions, to store data. Ions are several thousand times heavier than electrons and are therefore much easier to restrain. As a result, individual storage elements using ions can be reduced in size to almost atomic dimensions while retaining an enormous storage capacity.

In ReRAM cells, ions behave like batteries. The cell contains a metal oxide layer only a few nanometres thick that connects two electrodes. Electrical impulses move the ions in the metal oxide, producing redox processes. As a consequence, the level of electrical resistance changes, an effect that can be exploited for data storage. The stored information remains intact even when there is no electricity flow. At the same time, the ReRAM cells can be switched a thousand times faster and require a thousand times less energy than elements in conventional data storage devices.

The physical phenomenon on which such resistive cells are based was discovered as early as the 1960s, but scientists were initially unable to work out how it functioned in detail. In 2006 the group around Rainer Waser succeeded in deciphering the workings of this mechanism: the electrical resistance of a metal oxide layer changes abruptly and reversibly when voltage is briefly applied to it. In recent years, the development of ReRAMs has become one of the dominant trends in nanoelectronics, and today Rainer Waser and his colleagues are collaborating with companies such as Intel, Hewlett-Packard, Samsung and Toshiba.

Further examples from this research field »

Science and Technology of Nanosystems

This programme aims to develop new technologies for the synthesis and functionalisation of nanostructural materials and nanoparticles. Researchers are working on the development of novel process technologies designed to manufacture and structure nanomaterials with specific characteristics.

Advanced Engineering Materials

The focus of this programme is to develop customised alloys for lightweight construction and process technologies for a wide range of applications, such as extremely lightweight construction components, heat-resistant high-performance components and medical implants. The new functionalised materials developed in this programme are primarily utilized in membrane technologies for CO_2 separation and water purification, as well as in hydrogen production and storage.

BioSoft: Fundamentals for Future Technologies in the Fields of Soft Matter and Life Sciences

The properties and interactions of the underlying molecular

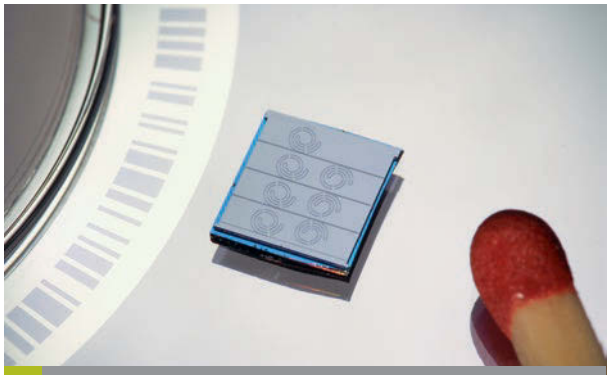
Algae grow inside the facade, nourished by CO_2 from the building's heating system. *Image: HZG*

Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)

HZG MEMBRANE TECHNOLOGY FOR BIOMASS PRODUCTION USING FLUE GAS

As part of the International Building Exhibition held in Hamburg in 2013, the biotech firm SSC GmbH installed the world's first bioreactor-facade on a residential apartment block. The facility is designed to produce both algae biomass and heating for the building. Inside the facade, algae grow using carbon dioxide from the flue gas produced by a biogas-driven heating system. In order to provide enough nourishment for the algae over a 200-square-metre surface, SSC uses a module equipped with CO_2-selective membranes developed by the HZG. This module increases the CO_2 concentration from 9 to 45 per cent by volume and has now been operating fault-free for a full year.

Optical microresonator made of silicon nitride. *Image: J. Pfeifle/KIT*



Karlsruhe Institute of Technology (KIT)

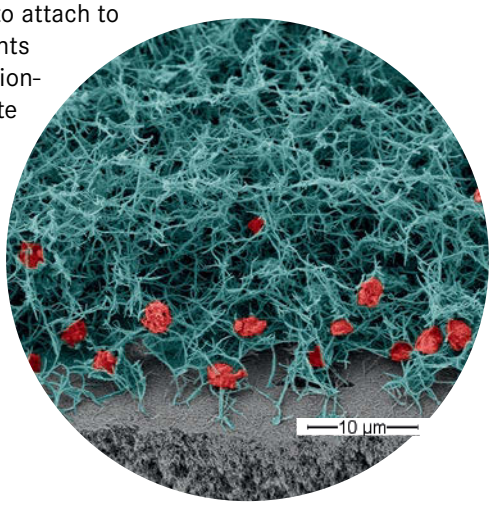
COMBS OF LIGHT ACCELERATE COMMUNICATION

The amount of data generated worldwide is growing continuously. With the help of light, this data can be transmitted rapidly and efficiently. Scientists from KIT and the Swiss École Polytechnique Fédérale de Lausanne (EPFL) have now demonstrated that data streams can be transmitted over distances of several hundred kilometres at a speed of 1.44 terabits per second using miniaturised optical frequency combs – this corresponds to the data volume produced by more than 100 million telephone conversations.

Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)

FUNCTIONALISATION OF IMPLANT SURFACES

The HZG Institute of Biomaterial Science has developed a technique for preventing undesirable blood-clotting on the rough surfaces of implants. It involves shielding the surfaces of the materials used in implants by means of multiply connected, highly branched ether-based elements. As a result, significantly less of the blood platelets and proteins, like fibrin, involved in blood-clotting are able to attach to implant surfaces. Implants made of materials functionalised in this way tolerate contact with blood better than conventional implants.

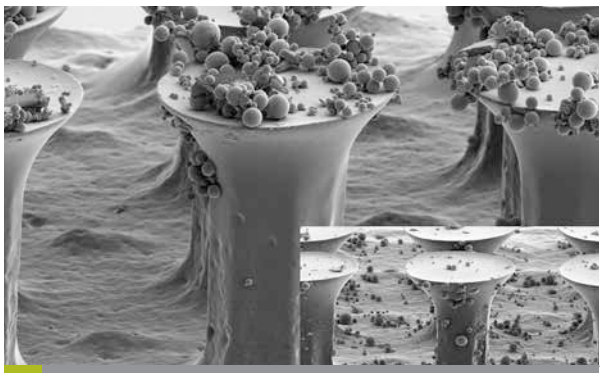


Contact between blood and materials with a rough surface (grey) can trigger clotting due to the adhesion of proteins such as fibrin (green) and blood platelets (red). *Image: HZG*

structures determine the characteristics and functions of the systems, such as living cells or cell groups. Research of this molecular structures aims to provide the knowledge required for the fabrication of functional nanoscale materials, the controlled manipulation of the flow properties of complex liquids, and the development of active molecular substances.

BioInterfaces in Technology and Medicine

Active biomaterials are becoming increasingly important in regenerative medicine, biological medical technology and biotechnical procedures. This programme deals with the entire developmental chain from biomaterials to toxicological and immunological evaluation to the design of implants and controlled drug delivery systems.



Scanning electron micrograph of micro-hairs modelled on the structures on a gecko's foot. The hairs are shown before and after cleaning (small image) by means of lateral friction contact with a smooth surface. *Image: M. Röhrig/KIT*

Karlsruhe Institute of Technology (KIT)

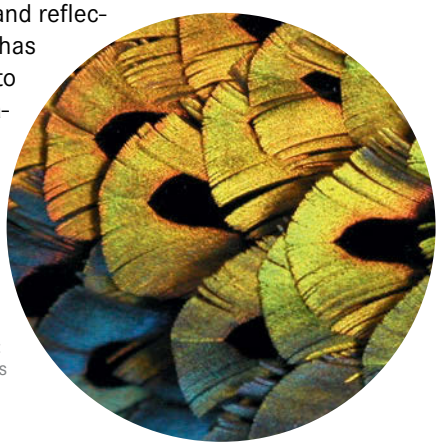
STICKING LIKE A GECKO

A gecko's feet have one clear advantage over adhesive tapes: even after repeated contact with dirt and dust they still adhere efficiently to smooth surfaces. Researchers at KIT and Carnegie Mellon University, Pittsburgh, have now developed the first adhesive tape that not only adheres to a surface as effectively as a gecko's foot, but also possesses similar self-cleaning properties. The tape retains its adhesive quality even after multiple uses and has obvious applications in areas such as food packaging and medical bandaging.

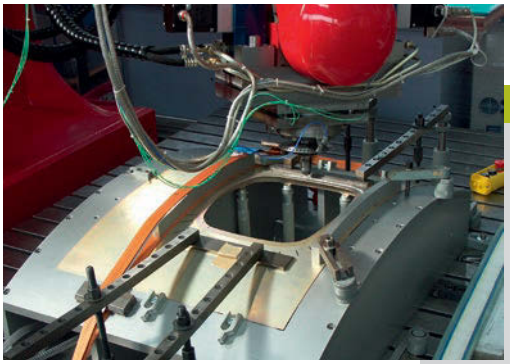
Forschungszentrum Jülich

THE IRIDESCENCE OF THE BIRD-OF-PARADISE

Male birds-of-paradise use the play of colours generated by their feathers to impress potential mates. Physicists from Jülich and Groningen in the Netherlands have now used computers to simulate the optical properties of the neck and breast feathers of one bird-of-paradise species. As they report, the results of the simulation show a very high degree of correspondence to previously measured light-scattering patterns and reflectance spectra. This work has enabled the researchers to provide a precise explanation of how the feathers' colours are generated through the reflection of light on the nanostructures within them.



Fascinating for both female birds-of-paradise and scientists: the plumage of the male Lawes's parotia. *Image: Justin Marshall*



Joining technology allows different materials to be stably welded together, for example, in aircraft construction. *Image: HZG*

Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)

NEW LICENSEE ADOPTS TECHNOLOGY "MADE IN GEESTHACHT"

Since 1999, solid state joining specialists at the HZG have been awarded twelve patents. This success has come from research on friction-based joining technologies used to connect very different materials, such as aluminium and steel or fibre-reinforced plastics and metals. Durable connections between such materials are vital to the development of lighter, damage-tolerant aircraft constructions and crash-proof vehicle components. A licensee cooperation agreement covering all twelve patents has now been signed with the machine construction specialist Loxin, which has its headquarters in Esquiroz, Spain.

Decoding the Human Brain

The aim of this programme is to use innovative imaging techniques in order to develop a structurally and functionally realistic multimodal model of the human brain for basic and translational research. Due to the complexity of the brain and the extensive changes during the life span, this goal can only be achieved by using high-performance computers.

Key Technologies for the Bioeconomy

Combining the two fields of biotechnology and plant science, this programme focuses on the development of future technologies that can be used to develop a sustainable bioeconomy. The work on industrial biotechnology concentrates on the biobased production of chemicals, pharmaceuticals and proteins using microbial and enzymatic processes. The research in the field of plant science will help to improve the quality of plant biomass and the production of plant-based chemicals and recyclables.

RESEARCH FIELD STRUCTURE OF MATTER

PROFESSOR HELMUT DOSCH
Vice-President of the Helmholtz Association,
Coordinator of the Research Field Structure of Matter,
Deutsches Elektronen-Synchrotron DESY

MISSION

Helmholtz researchers explore the constituent parts of matter and the forces operating between them on a wide range of levels, from elementary particles to complex functional materials to the systems and structures in the universe. Their work provides the basis for a better understanding of our universe and for the design of bespoke materials and active substances. Other important areas of research entail the development, construction and operation of large-scale devices and complex infrastructure. In this research field, the Helmholtz Association provides researchers from Germany and abroad with access to a variety of large-scale scientific facilities that in many cases are unique in the world, including detectors, data acquisition systems and particle accelerators. When completed, the European XFEL and the Facility for Antiproton and Ion Research (FAIR) – which are currently being constructed in Germany with the help of international partners – will provide internationally unrivalled radiation sources.

PROGRAMME STRUCTURE IN THE CURRENT FUNDING PERIOD

Seven Helmholtz centres are currently working together in four programmes dedicated to research into the structure of matter:

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

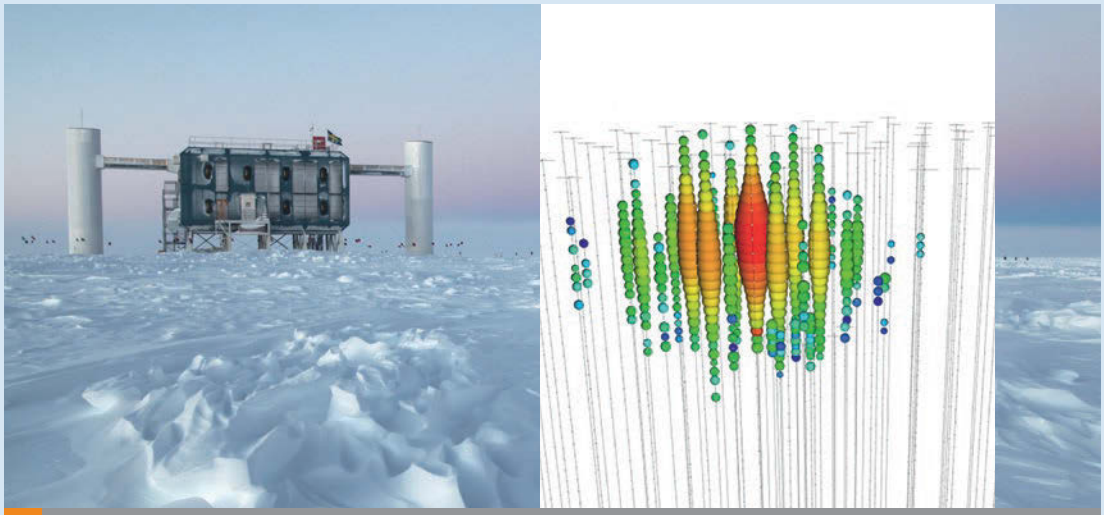
OUTLOOK

From 2015 onwards, this research field will be organized into three new programmes: “Matter and the Universe” will bring together three disciplines oriented to basic research – particle and astroparticle physics, the physics of hadrons and nuclei, and atomic and plasma physics. In the programme “From Matter to Materials and Life”, the operators of modern radiation sources will work together with researchers from the natural sciences, engineering and medicine to develop new materials and active substances and to investigate phenomena in condensed matter, electromagnetic plasmas and biological systems. The “Matter and Technologies” programme will focus on new technological concepts in areas such as particle acceleration, detector systems and the optimisation of high-performance computing and data storage. The goal of this restructuring process is to strengthen synergies and drive forward the development of innovative technologies.

PROGRAMMES IN THE COMING FUNDING PERIOD 2015–2019

Matter and the Universe

This programme combines particle and astroparticle physics, the physics of hadrons and nuclei, and atomic and plasma physics in order to answer fundamental questions about the origin, structure and future of the universe. It will also investigate the basic building blocks of matter, their interactions and the genesis of complex structures. These research questions are being explored by Helmholtz scientists in the context of large-scale international collaborations. In the three Helmholtz alliances “Physics at the Terascale”, “Extreme Densities and Temperatures – Cosmic Matter in the Laboratory” and “Astroparticle Physics”, they are able to take advantage of networks with colleagues from other



Data are collected by the IceCube detector in this Antarctic station (left) and are filtered and pre-evaluated there due to the facility's restricted transmission capacity. To the right, a high energy neutrino event is represented in a 3D graphic. *Image: IceCube/NSF*

Deutsches Elektronen-Synchrotron DESY

ICECUBE DETECTS HIGH-ENERGY NEUTRINOS FROM THE COSMOS

IceCube, the world's largest particle detector, has been collecting data since its completion in 2010. The results of this initial phase of operation suggest that this research is opening up a new branch of astronomy.
IceCube consists of over 5000 highly sensitive light detectors, which scientists spent six years installing at depths of up to 2.5 kilometres in one cubic kilometre of Antarctic ice. These sensors measure the extremely weak flashes of light produced by the very rare collisions of neutrinos with the ice. The goal of this experiment is to use the nearly mass-less neutrinos as unique messengers to detect high-energy events in the universe such as supernova explosions or other cosmic particle accelerators.
Between May 2010 and May 2013, researchers detected a total of 37 neutrinos from deep in the cosmos with energies exceeding 30 tera-electron volts (TeV). They included three with an energy of more than 1000 TeV. In December 2013, the highest-energy neutrino ever recorded in an experiment flew into the IceCube detector. Registering an almost unimaginable 2 peta-electron volts (2000 TeV), this single elementary particle had more than 300 times the energy of the protons that, from 2015 onwards, will smash into each other at almost the speed of light in the LHC, the world's most powerful particle accelerator. "These measurements are the first indications of extremely high-energy neutrinos coming from beyond our solar system and proof of the enormously energy-rich processes in the cosmos. We are currently witnessing the birth of neutrino astronomy," says Markus Ackermann, leader of the DESY research group participating in the IceCube project. A quarter of IceCube's sensors, or optical modules, were assembled and tested at DESY, and a significant part of the receiver electronics on the surface of the ice also come from Germany.
As yet, not enough high-energy events have been registered to provide evidence of clustering in time or space that could point to a particular cosmic source. However, as the number of recorded events increases over the coming years, scientists hope to be able to identify individual sources of high-energy neutrinos in the cosmos.

Further examples from this research field

research facilities, universities and Max Planck institutes. These collaborations are also providing researchers with access to unique large-scale facilities and infrastructure, including the Large Hadron Collider (LHC) at CERN, which is the world's most powerful particle accelerator, the GSI accelerator complex, and numerous large-scale detectors, underground laboratories and observatories that allow them to look deep into the cosmos.

From Matter to Materials and Life

In this programme, researchers use state-of-the-art radiation sources to investigate the structures, dynamic processes and functions of matter and materials. Their work involves close collaboration with universities and industry. Research emphases include transitional states in solids, molecules and biological systems, complex matter, tailored intelligent functions, transport systems, information technologies and

Some experiments require X-ray pulses with a specific time structure. At BESSY II such pulses are now available to users. *Image: K. Holldack/HZB*

Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)

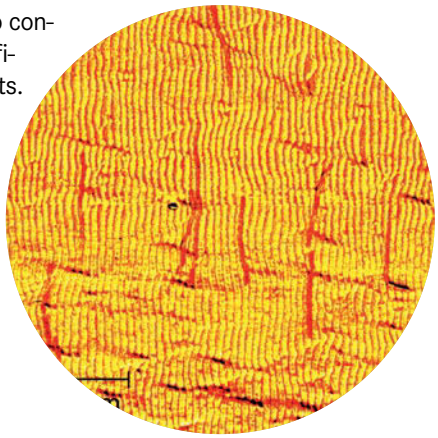
PULSE PICKING AT BESSY II

HZB physicists have developed a new method for "picking" individual pulses out of X-ray light generated using particle accelerators. "Materials scientists need such pulses to investigate quantum materials, superconductors and catalytic surface processes," explains Karsten Holldack. The new "pulse picking" technique is based on the excitation of certain oscillations in a specific electron bunch and represents a significant step in the development of the planned BESSY-VSR, which will provide researchers with customised variable X-ray pulses.

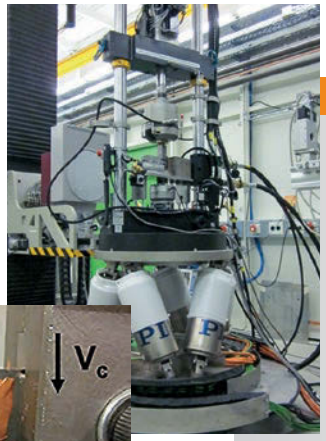
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)

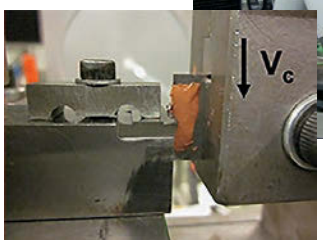
ALIGNED DNA WIRES FOR NANOELECTRONICS

HZDR scientists have developed a simple technique for the controlled arrangement of DNA nanostructures on silicon wafers. They irradiated the silicon with ions in order to produce regular wavelike nanopatterns on its surface. They then deposited nanotubes manufactured using the DNA origami technique onto the silicon. As a result of electrostatic interactions, these nanotubes independently aligned themselves along the waves. The next step will be to assemble the nanotubes into electronic circuits that can be used to construct smaller and more efficient electronic components.



It may look like a landscape of sand dunes, but it is actually smaller than a single grain of sand. As a result of electrostatic interactions, DNA nanotubes align with prefabricated patterns. *Image: A. Keller/HZDR*





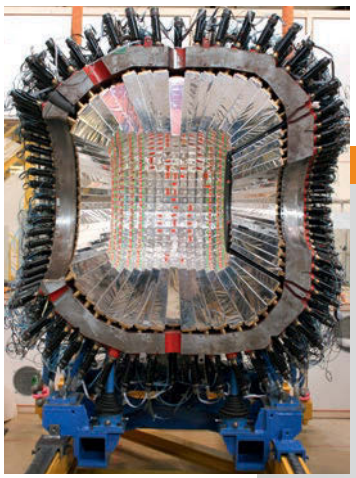
The processes that take place during the cutting of specific materials are investigated using X-ray beams generated by PETRA III. *Image: HZG*

Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)

MATERIALS PROCESSING – NEW SOLUTIONS FOR OLD PROBLEMS

Materials processing began with the first hand axe. Since then it has become ever more sophisticated and the matching of material, designated use and cutting method has become ever more complex. Together with partners from universities and industry, HZG is using high-energy X-rays to investigate what actually happens when a component made of a particular material is being processed and what goes on at the cutting surface: the tensions that are generated, the way grains reorient themselves, and the new phases that emerge. The results of this work are facilitating the optimisation of these extremely important industrial processes.

the design of new materials for the energy sector. A further goal is to improve the molecular structure of active substances and thus their properties. International research groups and collaborating partners are given access to photon, neutron and ion sources, high magnetic field laboratories and high-performance lasers. This research infrastructure includes ANKA, BER II, BESSY II, ELBE, FLASH, GEMS, HLD, IBC, JCNS and PETRA III, as well as international facilities in which the Helmholtz Association is involved such as the European XFEL and the Facility for Antiproton and Ion Research (FAIR).



A glimpse into the WASA detector: extremely precise measurements were facilitated by combining the detector with the COSY accelerator. *Image: Forschungszentrum Jülich*

Forschungszentrum Jülich

EXOTIC PARTICLE CONFIRMED

For decades physicists have been searching in vain for exotic bound states comprising more than three quarks. Now experiments at Jülich's COSY particle accelerator have shown that such complex particles actually exist in nature. The new measurements confirm results from 2011, when more than 120 scientists from eight countries discovered strong indications of the existence of an exotic dibaryon made up of six quarks.

The KASCADE experiment uses 252 detector stations distributed over an area of 200 by 200 metres. *Image: KIT*

Karlsruhe Institute of Technology (KIT)

GALACTIC KNEE AND EXTRAGALACTIC ANKLE

Data collected in the KASCADE-Grande experiment at KIT show that the so-called "knee" of cosmic radiation, a bend in the energy spectrum at high energies, occurs at different energies for light and heavy particles. In the case of light particles, scientists involved in the experiment have shown that the energy spectrum flattens out again beyond the "knee" and forms a kind of "ankle". This structure indicates that these particles are accelerated in galaxies other than the Milky Way.

GSI Helmholtz Centre for Heavy Ion Research

APPROACHING THE ISLAND OF STABILITY

An international research team working at the GSI accelerator facility has generated and observed several atoms of the as-yet nameless superheavy element with the atomic number 117. The fact that the measured properties of element 117 are in line with findings from the research centre in Dubna, Russia, fulfils an important condition required for official recognition of a new element. The experiment also produced atoms of the elements dubnium and lawrencium. Evidence of their presence required a highly refined measurement regime and represents a significant step towards identifying the "island of stability" of superheavy elements.

Element 117 was generated when calcium ions collided with this target wheel at GSI. *Image: Christoph Düllmann/GSI*

Matter and Technologies

This programme is a new initiative designed to pool the technological know-how of the different Helmholtz centres and to further develop the research field in strategic terms. Challenges and goals in this context include the exploration and development of new accelerator technologies and the development of detector systems for a broad range of applications. Researchers will also be focusing on the further development of high-performance computers and data storage. Another aim is to expand knowledge transfer between the Helmholtz centres, other research organisations and industry while also strengthening the ties between the individual research fields within the Helmholtz Association.

PERFORMANCE RECORD

The Helmholtz Association's mission is to conduct forward-looking research that contributes to solving the major and pressing problems of science, society and industry. The Helmholtz Association is the largest scientific organisation in Germany with around 37,000 staff members at 18 research centres and a total annual budget of more than 3.95 billion euros. Approximately 70 per cent of its funds are provided by Germany's federal and state governments at a ratio of 90 to 10. The centres raise around 30 per cent of the total budget themselves in the form of third-party funding. The association uses these funds to carry out cutting-edge research. The following pages present a range of informative indicators showing the Helmholtz Association's performance and potential.

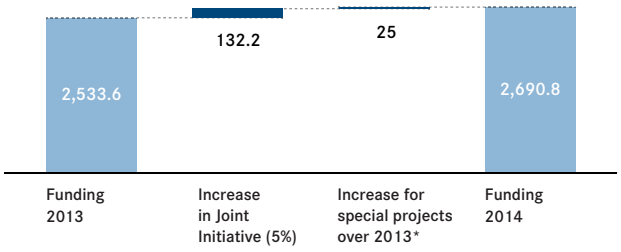
RESOURCES

Core funding for the Helmholtz Association for fiscal year 2014 increased to around 2.69 billion euros from approx. 2.53 billion euros during the previous year.

Development of resources

Growth 2013–2014

in million € (federal and state governments)

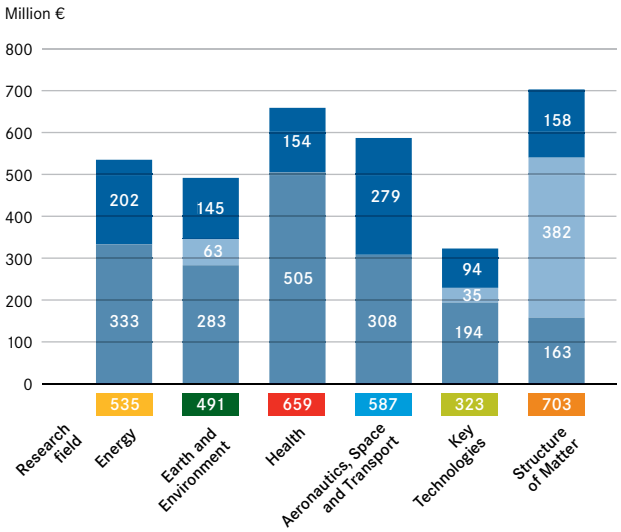


*German Centres for Health Research (federal/state governments) and Berlin Institute of Health

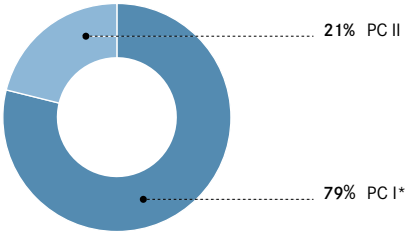
This increase comprises the five per cent boost in funding from the Joint Initiative for Research and Innovation II and the further increase in funding for certain special projects that receive additional financing from the state and federal governments. These projects include in particular the German Centres for Health Research, which are currently being established and expanded and are set to be completed by 2015 (total volume for 2013: 77 million euros). At first glance, it appears as if, with the exception of the research field Key Technologies, overall financial resources have been equally spread across all of the research fields. But upon closer inspection it becomes clear that the resources allocated to the research field Structure of Matter are invested primarily in research infrastructure and user platforms (Performance Category II). As a whole, in-house research in the Helmholtz Association's 30 research programmes (Performance Category I, or PC I) accounts for the predominant share of the allocated funds.

2013 budget showing core and third-party funding for the research fields

(including funds for the non-programme-linked research used to expand existing research programmes)



PC I* and PC II without third-party funds



Third-party funds
PC II
PC I*

*including funds for portfolio topics, the Helmholtz institutes, the Helmholtz share of the German Centres for Health Research and the Cancer Information Service

The bar chart shows core and third-party financing as actual costs for 2013. Actual costs are the funds that were in fact used by the research centres during the year under review.

Currently around 21 per cent of resources are allocated to research infrastructure and user platforms. This proportion, which has remained relatively constant over the past ten

"As clearly shown by the indicators, the Helmholtz Association was able to further improve its scientific performance over the past year. The quality of scientific publications is impressively documented by the Nature Publishing Index, which ranks the Helmholtz Association fifth among other major research organisations and institutions worldwide, with an upward trend over the years."

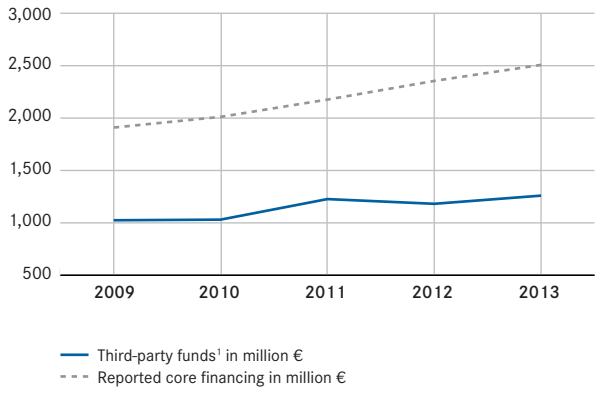
DR. ROLF ZETTL, Managing Director of the Helmholtz Association

years, is expected to increase slightly after two additional large-scale facilities (the European free-electron laser XFEL and the accelerator facility FAIR) are put into operation.

Third-party funding

In addition to core financing, a substantial amount of third-party funding – raised primarily in competitions – is available to the Helmholtz centres. In 2013 the Helmholtz Association acquired third-party funds totalling 1.26 billion euros, representing an increase of seven per cent over the previous year.

Third-party funds



[1] Project sponsorships have been taken into account since 2011 (approx. 186.7 million euros in 2013). The Helmholtz institutes, the German Centres for Health Research and the Cancer Information Service accounted for around one million euros in third-party funds.

Sources: Progress Reports of the Helmholtz Centres, 2009 to 2013

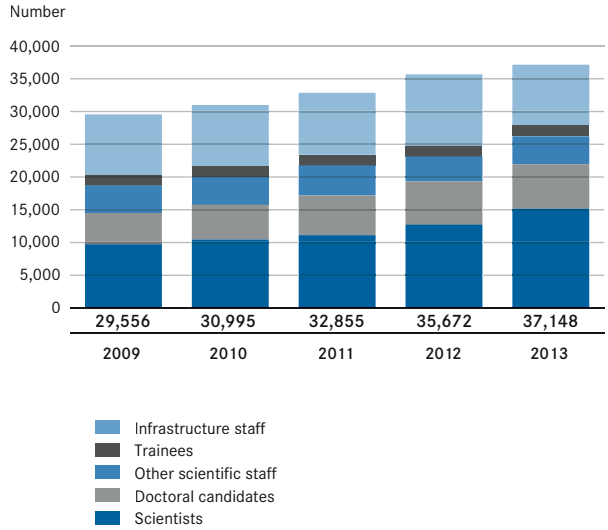
The grants acquired through the EU's Research Framework Programme account for a particularly important share of third-party funding. The association has received a consistently high level of EU funding over the years. In 2013, the Helmholtz centres participated in 288 projects that were funded for the first time by the European programme – an increase of 27 per cent over 2012.

Acquired EU research funds

in T€	2009	2010	2011	2012	2013
Funds from the EU for research and development	131,769	118,477	146,188	126,936	124,412

Staff developments

Staff developments



The constantly expanding availability of financial resources has made it possible to expand the staff at the Helmholtz centres. However, these rising costs must be offset by the increase in funding from the Joint Initiative, and in the case of certain material expenses (mainly energy) these costs lie above budgetary growth. For this reason, staff expansion lags behind that of resources and is concentrated in centres that pursue activities receiving special funding (particularly the German Centres for Health Research). In 2013 the growth rates of recent years could not be maintained because they were bolstered by a variety of special effects (the integration of the Helmholtz-Zentrum Dresden-Rossendorf in 2011 and GEOMAR Helmholtz Centre for Ocean Research Kiel in 2012). Staff growth in the different personnel categories was relatively uniform.

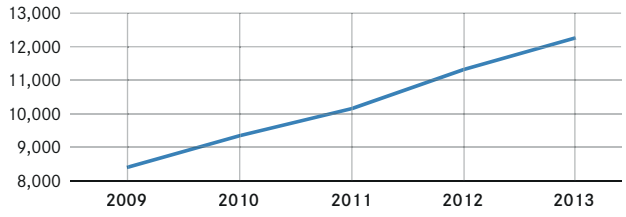
Detailed information on the Helmholtz Association's resources can be found on pages 42–43, broken down by research field and research centre.

SCIENTIFIC PERFORMANCE

Research performance

Publications are a key measure of scientific productivity. There has been a clear increase in the number of publications by Helmholtz scientists. In 2013, 12,255 publications were published in ISI-indexed scientific journals and an additional 3,763 in peer-reviewed journals. The number of ISI-indexed publications has grown by eight per cent over the previous year and by a total of 46 per cent since 2009.

ISI-indexed publications



A good measure of the quality of research findings is the number of times they are published in prestigious journals. The Nature Publishing Group compiles an international ranking of institutions on the basis of the number of publications in *Nature* and the monthly *Nature Research Journals*. Based on the number of articles its scientists published, the Helmholtz Association was ranked five in 2013.

Nature Publishing Index 2013

Rank	Institution	Articles
1	Harvard University, US	387
2	French National Centre for Scientific Research (CNRS), France	297
3	Massachusetts Institute of Technology (MIT), US	228
4	Max Planck Society, Germany	216
5	Helmholtz Association, Germany	201
6	National Institutes of Health (NIH), US	181
7	Stanford University, US	170
8	Chinese Academy of Sciences (CAS), China	165
9	University of Cambridge, UK	151
10	University of Oxford, UK	136

Source: http://www.natureasia.com/en/publishing-index/global/

In addition to the ranking by number of articles, the Nature Publishing Index offers a corrected count that takes into account the degree of cross-institutional collaboration. In this case a publication written in cooperation with other institutions is assigned to the participating institutions on a pro rata basis. Because of the Helmholtz Association's numerous collaborations, many publications by its scientists are thus weighted proportionately. In the corrected count of the Nature Publishing Index, the Helmholtz Association was ranked 13 in 2013, up from 19 in 2012 and above many other renowned institutions such as University College London (14) or the ETH Zurich (21).

User platforms

Along with scientific performance, an important issue for the Helmholtz Association is the extent to which it has fulfilled its mission to provide researchers with access to its unique research facilities. In 2013, availability decreased somewhat over the previous year because of maintenance work on one large-scale device.

Helmholtz Association research facilities

	Type of use	Actual value 2012	Actual value 2013*
Availability		80.9%	79.6%
Utilisation	Internal Helmholtz scientists	32.6%	33.4%
	External scientists	67.3%	63.5%

* One hundred per cent utilisation was not achieved in 2013 due to the partial malfunction and reduced capacity of one large-scale device, which was therefore not available to the usual extent.

The table shows average values for all large-scale devices at the Helmholtz Association. Explanation of measurement categories: Average availability: number of days per year when the device was available (without maintenance or downtime), given in per cent. Average utilisation: the share of the total available capacity that was actually used by scientists. The unit of capacity measurement is device-specific. Internal and external use added together total a maximum of 100 per cent.

National collaboration

In addition to international collaborations, networks in Germany, especially those involving universities, are extremely important for the Helmholtz centres. Together with the number of joint appointments, participation in both the programmes of the German Research Foundation and the Excellence Initiative (generally with universities) shows the extent to which these networks have been implemented.

Joint appointments

	2009	2010	2011	2012	2013
Joint appointments with universities, W2 and W3 staff	262	319	374	452	499

German Research Foundation (DFG)

	2009	2010	2011	2012	2013
Research centres	1	1	1	2	2
Collaborative research centres	59	61	64	68	67
Priority programmes	50	50	52	52	49
Research units	53	56	62	58	61

The table illustrates the success of the Helmholtz centres in the competitions held by the German Research Foundation (DFG). The count only includes projects in which the participating researchers noted their Helmholtz affiliation in their applications. In a number of cases, Helmholtz researchers who were appointed to positions jointly with universities applied for projects with other scientists within the scope of their university activities. If these projects are also included, the figures for 2013 increase to 94 collaborative research centres, 55 priority programmes and 70 research units.

Participation in the Excellence Initiative

	Excellence clusters	Graduate schools	Institutional concepts
1st phase	13	15	3
2nd phase	19	17	8

International exchange

The Helmholtz Association's research facilities are open to scientists from around the world. For this reason – and also because of the scientific appeal of the Helmholtz centres – the number of foreign researchers has risen steadily. The Helmholtz Association has thus been successful in expanding international academic exchanges and strengthening its international character.

Foreign scientists at the Helmholtz centres

	2009	2010	2011	2012	2013
Postgraduate	1,085	1,192	1,425	1,705	1,921
Postdoc	695	825	940	1,103	1,267
Experienced scientists/ university teachers	1,531	1,677	1,680	2,175	2,477
Guest scientists	2,308	2,406	3,153	2,577	2,669
No categorisation possible/no information	172	167	165	205	189
Total	**5,791**	**6,267**	**7,363**	**7,765**	**8,523**

Talent management

Promoting young scientists is another key component of the Helmholtz Association's strategy for the future. Junior research groups are supported directly by the Helmholtz centres or by grants from the Initiative and Networking Fund. The goal is to foster the early scientific independence of talented young researchers and to provide them with reliable career planning. A total of 43 per cent of the Helmholtz Young Investigators Groups and 29 per cent of other junior research groups are now led by women.

Junior research groups

		Total	Women
Junior research group leaders	**Leaders of Helmholtz Young Investigators Groups** (funded by the Initiative and Networking Fund within the framework of the Helmholtz Young Investigators Group programme)	93	40
	Leaders of other junior research groups (e.g., junior research groups at the centres, Emmy Noether groups, etc.)	139	40

The Helmholtz Association is continuing to expand its programmes to promote doctoral candidates. It has increased the number of its graduate and research schools in order to provide as many candidates as possible with a structured education based on defined quality standards. The success of these activities is reflected in the 20 per cent rise in completed doctoral degrees in 2013 over the previous year.

Doctoral work

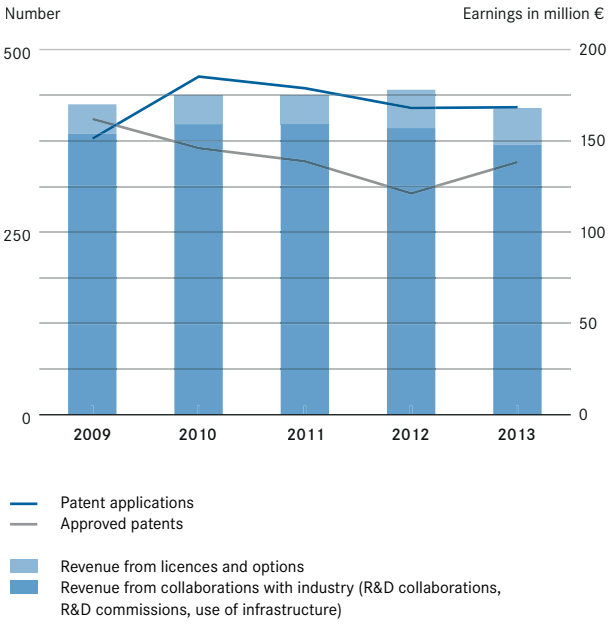
	31.12.09	31.12.10	31.12.11	31.12.12	31.12.13
Number of funded graduate and research schools*	48	49	75	84	95
Number of supervised doctoral candidates**	4,797	5,320	6,062	6,635	6,789
Number of completed dissertations	848	783	822	803	964

* including 12 graduate schools supported by the DFG
** including the individuals who use the research infrastructure of the Helmholtz Association

Technology transfer

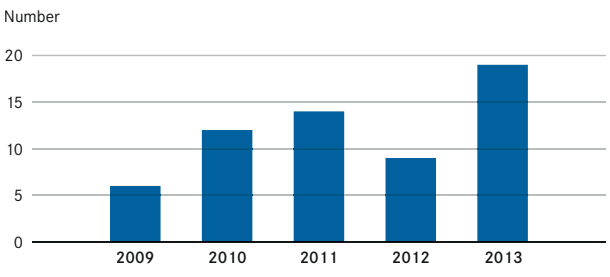
Making research findings available to industry and society is part of the Helmholtz Association's mission. For this reason it has invested heavily in the area of technology transfer in recent years, especially (at the association level) in the establishment of a Validation Fund. Grants from this fund make it possible to "refine" certain research findings to the point where they can be commercialised. The steady number of patent applications is attributable to the increasing professionalisation of the association's technology transfer offices, which, more selectively than in the past, support projects that can be expected to have commercial success.

Technology transfer



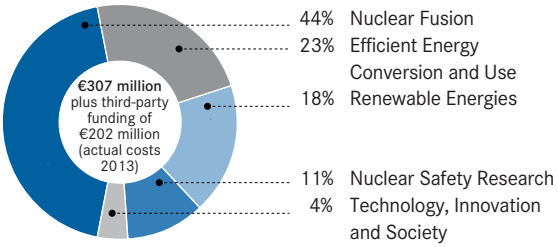
The trend in the area of research spin-offs is also highly positive. A variety of instruments and incentives are available from both the centres and the association to promote such spin-offs. In addition, efforts are made to support the newly formed companies themselves, e.g., through exchange platforms with industry. This area will also be expanded in the future.

Research spin-offs



COSTS AND STAFF

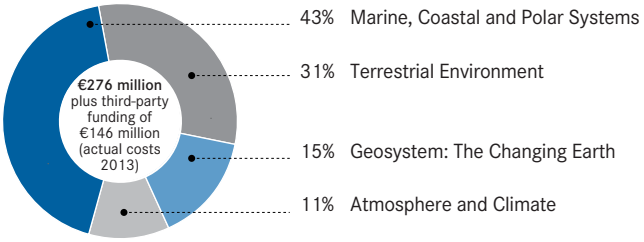
Structure of the Research Field Energy
Target costs of core financing 2013: 307 million euros*
(incl. share of non-programme-linked research)



* No target costs are available for the HZDR for this research field.
* Plus portfolio funds of €16 million.

Source: Progress Report of the Centres 2013

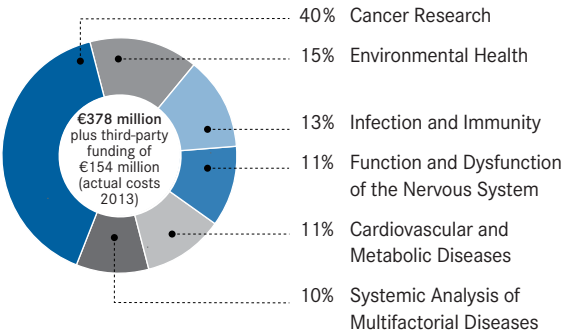
Structure of the Research Field Earth and Environment
Target costs of core financing 2013: 276 million euros*
(incl. share of non-programme-linked research)



* No target costs are available for GEOMAR for this research field.
* Plus portfolio funds of €12 million.

Source: Progress Report of the Centres 2013

Structure of the Research Field Health
Target costs of core financing 2013: 378 million euros*
(incl. share of non-programme-linked research)



* Plus funds of €36 million for the Helmholtz share of the German Centres for Health Research and the Helmholtz Institute Saarbrücken.
* No target costs are available for the HZDR and the DZNE for this research field.
* Plus portfolio funds of €9 million.

Source: Progress Report of the Centres 2013

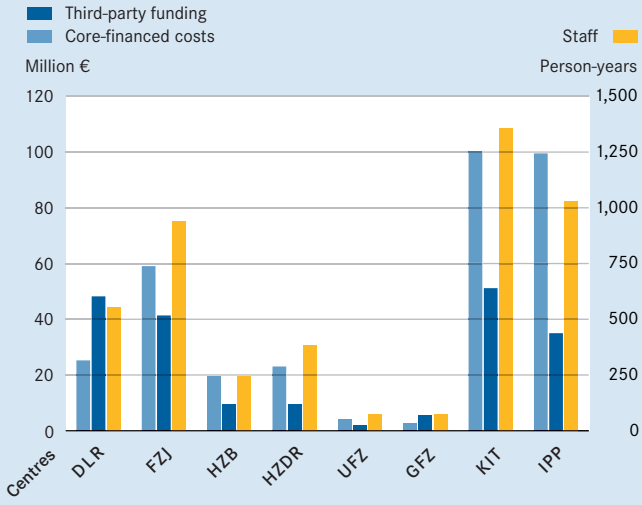
COSTS AND STAFF

COSTS AND STAFF 2013 for the Helmholtz Association, overview	Actual core-financed costs T€	Third-party funds T€	Total T€	Total staff PYs [1]
Research fields, total[2]	2,261,337	1,036,664	3,298,001	29,185
Non-programme-linked research, total[3]	57,933	28,543	86,476	630
Special tasks, total[4]	18,863	7,784	26,647	183
Project sponsorships, total		186,651	186,651	1,871
Helmholtz Association, total	**2,338,133**	**1,259,642**	**3,597,775**	**31,869** [5]

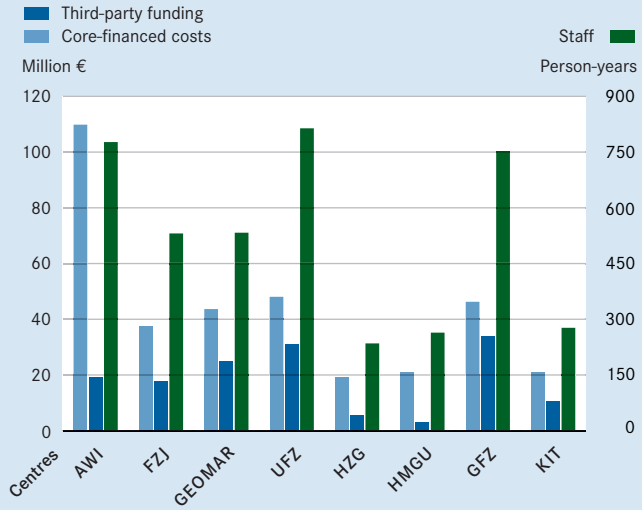
[1] Person-years. [2] In addition to the six research fields, this category includes funds for portfolio topics, the Helmholtz institutes, the Helmholtz share of the German Centres for Health Research and the Cancer Information Service. [3] The funds for non-programme-linked research can amount to a maximum of 20 per cent of all acquired programme funding. If the centres use these funds to strengthen existing research programmes, the funds are assigned directly to the costs of the respective programmes. [4] Mainly involving the dismantling of nuclear facilities. [5] Expressed as natural persons, the Helmholtz Association has 37,148 employees.

Research Field Energy	Core-financed actual costs T€	Third-party funds T€	Total T€	Total stuff PYs [1]
German Aerospace Center (DLR)	25,239	48,219	73,458	553
Forschungszentrum Jülich (FZJ)	59,067	41,365	100,432	942
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	19,556	9,255	28,811	244
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	23,042	9,258	32,300	385
Helmholtz Centre for Environmental Research – UFZ	3,978	1,935	5,913	74
Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences	2,610	5,568	8,178	72
Karlsruhe Institute of Technology (KIT)	100,394	51,163	151,557	1,358
Max Planck Institute for Plasma Physics (IPP)	99,532	35,008	134,540	1,030
Research Field Energy, total	**333,418**	**201,771**	**535,189**	**4,658**
Research Field Earth and Environment				
Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI)	109,844	19,239	129,083	777
Forschungszentrum Jülich (FZJ)	37,364	17,578	54,942	531
GEOMAR Helmholtz Centre for Ocean Research Kiel	42,938	24,980	67,918	531
Helmholtz Centre for Environmental Research – UFZ	48,061	30,975	79,036	814
Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)	19,191	5,326	24,517	235
Helmholtz Zentrum München – German Research Center for Environmental Health (HMGU)	21,028	2,966	23,994	264
Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences	46,274	34,066	80,340	751
Karlsruhe Institute of Technology (KIT)	21,045	10,440	31,485	277
Research Field Earth and Environment, total	**345,745**	**145,570**	**491,315**	**4,180**
Research Field Health				
German Cancer Research Center (DKFZ)	144,014	56,715	200,729	2,248
German Center for Neurodegenerative Diseases (DZNE)	78,934	5,133	84,067	597
Forschungszentrum Jülich (FZJ)	29,809	5,762	35,571	363
GSI Helmholtz Centre for Heavy Ion Research	3,908	1,225	5,133	83
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	13,269	1,613	14,882	160
Helmholtz Centre for Infection Research (HZI)	47,743	23,606	71,349	699
Helmholtz Centre for Environmental Research – UFZ	4,726	655	5,381	51
Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)	9,285	4,160	13,445	150
Helmholtz Zentrum München – German Research Center for Environmental Health (HMGU)	112,152	31,650	143,802	1,604
Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch	60,807	23,432	84,239	887
Research Field Health, total	**504,647**	**153,951**	**658,598**	**6,842**
Research Field Aeronautics, Space and Transport				
German Aerospace Center (DLR)	308,104	278,599	586,703	5,010
Research Field Aeronautics, Space and Transport, total	**308,104**	**278,599**	**586,703**	**5,010**
Research Field Key Technologies				
Forschungszentrum Jülich (FZJ)	108,279	44,099	152,378	1,298
Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)	25,684	6,392	32,076	328
Karlsruhe Institute of Technology (KIT)	95,227	43,307	138,534	1,368
Research Field Key Technologies, total	**229,190**	**93,798**	**322,988**	**2,994**
Research Field Structure of Matter				
Deutsches Elektronen-Synchrotron DESY	211,519	82,164	293,683	2,053
Forschungszentrum Jülich (FZJ)	45,549	11,935	57,484	486
GSI Helmholtz Centre for Heavy Ion Research	103,038	34,804	137,842	1,350
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	89,678	12,507	102,185	672
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	34,418	8,507	42,925	414
Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)	7,779	2,208	9,987	82
Karlsruhe Institute of Technology (KIT)	48,252	10,850	59,102	444
Research Field Structure of Matter, total	**540,233**	**162,975**	**703,208**	**5,501**

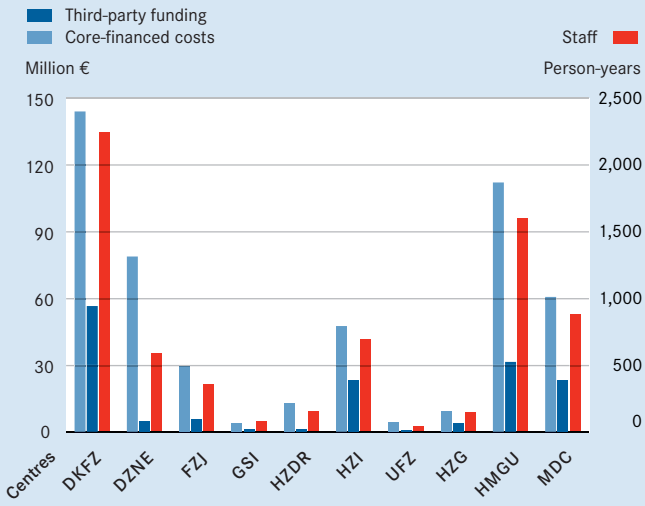
Research Field Energy



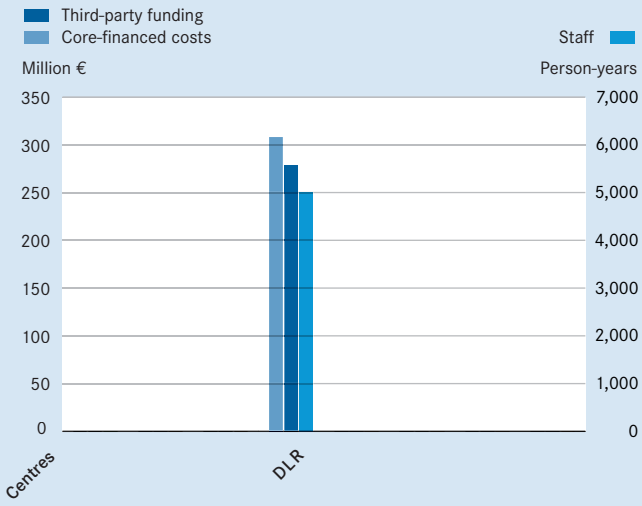
Research Field Earth and Environment



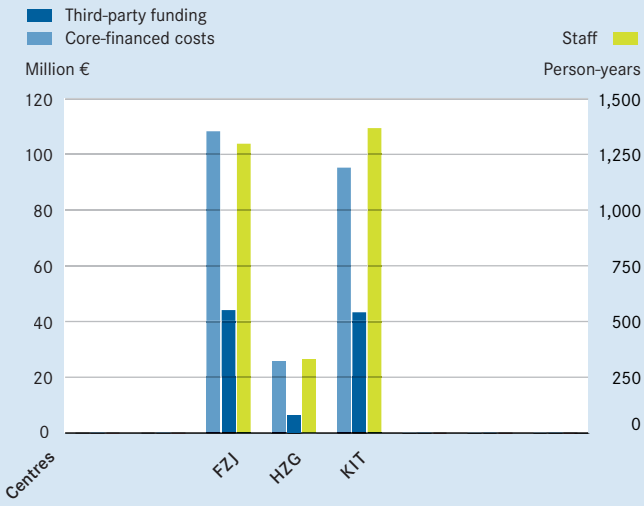
Research Field Health



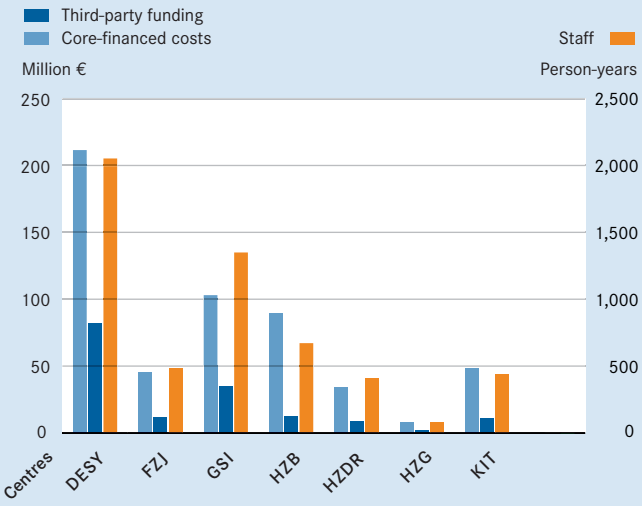
Research Field Aeronautics, Space and Transport



Research Field Key Technologies

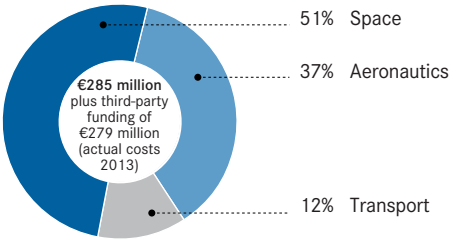


Research Field Structure of Matter



Structure of the Research Field Aeronautics, Space and Transport Target costs of core financing 2013: 285 million euros*

(incl. share of non-programme-linked research)

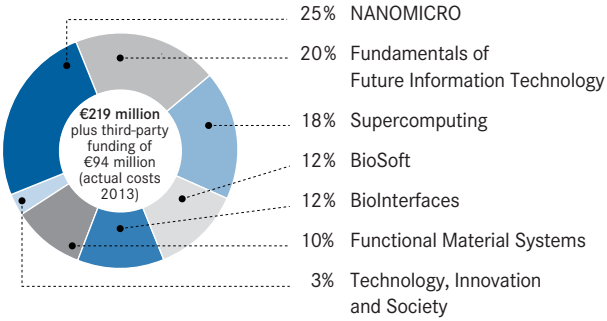


* Plus portfolio funds of €9 million.

Source: Progress Report of the Centres 2013

Structure of the Research Field Key Technologies Target costs of core financing 2013: 219 million euros*

(incl. share of non-programme-linked research)

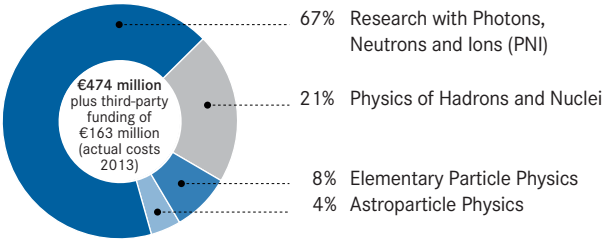


* Plus funds of €6 million for the Helmholtz Institute Ulm.
* Plus portfolio funds of €10 million.

Source: Progress Report of the Centres 2013

Structure of the Research Field Structure of Matter Target costs of core financing 2013: 474 million euros*

(incl. share of non-programme-linked research)



* No target costs are available for the HZDR for this research field.
* Plus funds of €11 million for the Helmholtz Institutes of Mainz and Jena.
* Plus portfolio funds of €9 million.

Source: Progress Report of the Centres 2013

2013

COSTS AND STAFF BY CENTRE

The Helmholtz Association's annual budget consists of core financing and third-party funding. A total of 90 per cent of core financing is provided by the federal government and 10 per cent comes from the federal states in which the member centres are located. The centres raise around 30 per cent of the total budget themselves in the form of third-party funding. Due to the Helmholtz Association's strategic focus on six research fields, the total budget is broken down for the fiscal year 2013 according to the research fields and the centres. This overview is supplemented by information on the number of staff members expressed in person-years.

Costs and staff by centre, 2013

	Actual core-financed costs T€	Third-party funds T€	Total T€	Total staff PYs [1]
Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI)	109,844	19,239	129,083	777
Deutsches Elektronen-Synchrotron DESY	211,519	82,164	293,683	2,053
German Cancer Research Center (DKFZ)	144,014	56,715	200,729	2,248
German Aerospace Center (DLR)	333,343	326,818	660,161	5,563
German Center for Neurodegenerative Diseases (DZNE)	78,934	5,133	84,067	597
Forschungszentrum Jülich (FZJ)	280,068	120,738	400,806	3,619
GEOMAR Helmholtz Centre for Ocean Research Kiel	42,938	24,980	67,919	531
GSI Helmholtz Centre for Heavy Ion Research	106,945	36,029	142,974	1,433
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	109,234	21,761	130,995	916
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	70,729	19,378	90,108	960
Helmholtz Centre for Infection Research (HZI)	61,939	18,086	80,025	794
Helmholtz Centre for Environmental Research – UFZ	47,743	23,606	71,349	699
Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)	56,765	33,565	90,330	939
Helmholtz Zentrum München – German Research Center for Environmental Health (HMGU)	133,180	34,616	167,796	1,868
Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences	48,884	39,634	88,518	824
Karlsruhe Institute of Technology (KIT)	264,919	115,759	380,678	3,446
Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch	60,807	23,432	84,239	887
Max Planck Institute for Plasma Physics (IPP)	99,532	35,008	134,540	1,030
Non-programme-linked research	**57,933**	**28,543**	**86,476**	**630**
Special tasks[2]	**18,863**	**7,784**	**26,647**	**183**
Project sponsorships		**186,651**	**186,651**	**1,871**
Helmholtz Association, total	**2,338,134**	**1,259,640**	**3,597,774**	**31,869**

[1] Person-years. [2] Mainly involving the dismantling of nuclear facilities.

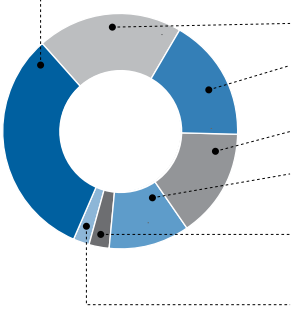
THIRD ROUND OF PROGRAMME-ORIENTED FUNDING, 2015–2019

In spring 2014 a total of 17 programmes and 13 research facilities were evaluated in the research fields Energy, Key Technologies and the reorganised area of Matter. For these fields, the third period of programme-oriented funding (POF) will begin in 2015. The following section presents programme financing for 2015 as recommended by the Helmholtz Senate on the basis of its reviews.

Energy

The evaluation of the seven programmes in this research field took place between January and March 2014. The reviewers welcomed the realignment of the field, which has been augmented with two additional programmes and given a stronger focus on topics related to the clean energy transition. The reviewers recommended further expanding the cross-programme strategy for a sustainable energy system. Financing recommendations for the entire funding period, expressed on a cost basis, total 2,128 million euros.

Structure of the Research Field Energy
Core-financed costs
Recommendations for 2015–2019: 2,128 million euros

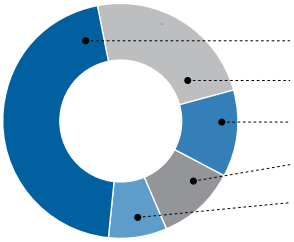


32% Nuclear Fusion
20% Energy Efficiency, Materials and Resources
17% Storage Systems and Cross-Linked Infrastructures
15% Renewable Energies
11% Nuclear Waste Management and Safety as well as Radiation Research
3% Future Information Technology – Fundamentals, Novel Concepts and Energy Efficiency (FIT)
2% Technology, Innovation and Society

MATTER

The research field Matter not only has a new name, but also a new programme structure. The evaluation of the three programmes, which took place between February and April 2014, confirmed the importance of this restructuring process. Since this research field is closely linked to the development, construction and operation of large-scale devices, one of its programmes is devoted exclusively to technological research. For the entire funding period, the financing recommendations, expressed on a cost basis, total 3,071 million euros, including 1,420 million euros for Performance Category II (PC II) financing and 740 million euros for the PC II facilities that are currently under construction.

Structure of the Research Field Matter
Core-financed costs
Recommendations for 2015–2019: 3,071 million euros

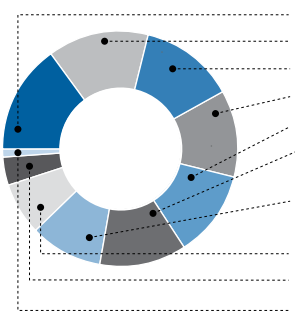


*PC II facilities: PETRA III (DESY) €366 million; FLASH (DESY) €231 million; BESSY II (HZB) €216 million; BER II (HZB) €150 million; ANKA (KIT) €115 million; JCNS (FZJ) €101 million; ELBE (HZDR) €51 million; GridKa (KIT) €51 million; ISZ (HZDR) €42 million; HLD (HZDR) €34 million; TIER II (DESY) €33 million; GEMS (HZB) €31 million
**PC II facilities under construction: FAIR (GSI/FZJ) €544 million; XFEL (DESY) €196 million

Key Technologies

The nine programmes in this research field were evaluated between January and March 2014. The reviewers confirmed the significant scientific and strategic relevance of these programmes and recommended that all the activities in the field of "big data" be more further pooled using an overarching strategy and the interdisciplinary alliance "Large Scale Data Management and Analysis". Financing recommendations for the entire funding period, expressed on a cost basis, total 1,431 million euros, including 54 million euros for PC II financing.

Structure of the Research Field Key Technologies
Core-financed costs
Recommendations for 2015–2019: 1,431 million euros



The third round of programme-oriented funding for 2015 to 2019 for the reviewed research fields

	Core-financed costs T€
Research Field Energy	
German Aerospace Center (DLR)	154,740
Forschungszentrum Jülich (FZJ)	464,081
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	160,177
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	176,629
Helmholtz Centre for Environmental Research – UFZ	26,171
Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences	15,016
Karlsruhe Institute of Technology (KIT)	641,162
Max Planck Institute for Plasma Physics (IPP)	489,733
Research Field Energy, total	**2,127,710**
Research Field Matter	
Deutsches Elektronen-Synchrotron DESY	1,260,176
Forschungszentrum Jülich (FZJ)	246,229
GSI Helmholtz Centre for Heavy Ion Research	546,555
Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)	436,481
Helmholtz-Zentrum Dresden-Rossendorf (HZDR)	262,514
Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)	43,206
Karlsruhe Institute of Technology (KIT)	276,214
Research Field Matter, total	**3,071,376**
Research Field Key Technologies	
Forschungszentrum Jülich (FZJ)	769,062
Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research (HZG)	216,856
Karlsruhe Institute of Technology (KIT)	445,213
Research Field Key Technologies, total	**1,431,130**

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As of October 2014

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Professor Jürgen Mlynek

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Professor Holger Hanselka, President of the Karlsruhe Institute of Technology

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Professor Georg Teutsch, Scientific Director of the Helmholtz Centre for Environmental Research – UFZ

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Professor Günther Wess, Scientific Director of the Helmholtz Zentrum München – German Research Center for Environmental Health

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Coordinator of the Research Field Aeronautics, Space and Transport
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Coordinator of the Research Field Key Technologies
Professor Achim Bachem (until 30 June 2014); Professor Wolfgang Marquardt (from 1 July 2014), Chairman of the Board of Directors, Forschungszentrum Jülich

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Coordinator of the Research Field Structure of Matter
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Professor Jürgen Klenner, former Senior Vice-President, Structure & Flight Physics, EADS Toulouse, France

Martina Koederitz, General Manager of IBM Germany, Ehningen

Professor Vera Lüth, SLAC National Accelerator Laboratory, Stanford, US

Professor Volker Josef Mosbrugger, Director of the Senckenberg Research Institute and Nature Museum, Frankfurt am Main

Hildegard Müller, Chairwoman of the General Executive Management Board, German Association of Energy and Water Industries (BDEW), Berlin

Professor Robert Rosner, University of Chicago, US

Professor Konrad Samwer, University of Göttingen

Professor Louis Schlapbach, former CEO of EMPA, ETH Domain, Switzerland

Professor Babette Simon, Chief Medical Officer and Executive Board of the University Medical Center, Johannes Gutenberg University Mainz

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N.N., State Secretary, Federal Ministry for Economic Affairs and Energy, Berlin

Michael Kretschmer, Member of the German Bundestag, Berlin

Jens Lattmann, State Councillor, Department of Finances of the City of Hamburg

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René Röspel, Member of the German Bundestag, Berlin

Professor Sabine von Schorlemer, Minister of Science and the Arts, State of Saxony, Dresden

Professor Peter Strohschneider, President of the German Research Foundation, Bonn

Professor Johanna Wanka, Federal Minister of Education and Research, Bonn

GUESTS

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Professor Thomas Brey, Chairman of the Committee of Scientific-Technical Councils, Alfred Wegener Institute, Helmholtz Centre for Polar and Ocean Research, Bremerhaven

Professor Helmut Dosch, Vice-President of the Helmholtz Association, Chairman of the Board of Directors, Deutsches Elektronen-Synchrotron DESY, Hamburg

Professor Holger Hanselka, Vice-President of the Helmholtz Association, President of the Karlsruhe Institute of Technology

Professor Horst Hippler, President of the German Rectors' Conference, Bonn

Professor Matthias Kleiner, President of the Leibniz Association, Berlin

Elsbeth Lesner, Representative of the Staff and Works Councils of the Helmholtz Centres, Helmholtz-Zentrum Berlin für Materialien und Energie (HZB)

Professor Wolfgang Marquardt, Vice-President of the Helmholtz Association, Chairman of the Board of Directors, Forschungszentrum Jülich

Professor Manfred Prenzel, Chairman of the German Council of Science and Humanities, Cologne

Professor Martin Stratmann, President of the Max Planck Society for the Advancement of the Sciences, Munich

Professor Hans Ströher, Vice-Chairperson of the Scientific-Technical Councils of the Helmholtz Centres, Forschungszentrum Jülich

Professor Georg Teutsch, Vice-President of the Helmholtz Association, Scientific Director of the Helmholtz Centre for Environmental Research – UFZ, Leipzig

Professor Günther Wess, Vice-President of the Helmholtz Association, Scientific Director of the Helmholtz Zentrum München – German Research Center for Environmental Health

Dr. Heike Wolke, Vice-President of the Helmholtz Association, Administrative Director of the Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch

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Dr. Rolf Zettl, Managing Director of the Helmholtz Association

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Research Field Health
Professor Irmgard Sinning, Director of the Heidelberg University Biochemistry Centre

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

Research Field Key Technologies
Professor Dieter Jahn, former Senior Vice-President of Science Relations and Innovation Management, BASF, Ludwigshafen

Research Field Structure of Matter
Professor Joël Mesot, Director of the Paul Scherrer Institute, Villigen, Switzerland

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Professor Konrad Samwer, University of Göttingen

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Professor Felicitas Pauss, CERN, Switzerland

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Professor William Stirling, CEA, France

Matter and Technology:
Professor Francesco Sette, ESRF, France

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*Abbreviations:
SdöR: foundation under public law
SdpR: foundation under private law
KdöR: public body
e.V.: registered association
GmbH: limited liability company

HELMHOLTZ ASSOCIATION GOVERNANCE STRUCTURE

COMMITTEE OF FUNDING BODIES

The Committee of Funding Bodies – made up of the federal government and the host states – defines research policy guidelines for the individual research fields for a period of several years. It also appoints members to the Helmholtz Senate.

SENATE

Together with the Assembly of Members, the Senate, which is made up of external experts, is the Helmholtz Association's central decision-making body. It consists of both ex-officio members – representatives of the federal and state governments, the German Bundestag and scientific organisations – and figures from science and industry. The latter are elected for three years. The Senate deliberates on all important matters and is responsible for electing the president and the vice-presidents.

SENATE COMMISSIONS

The Senate has established Senate Commissions to prepare for discussions on programme funding (based on programme reviews) and the setting of investment priorities. The Senate Commissions consist not only of permanent members – ex-officio representatives of the federal and state authorities and external experts for the six research fields – but also of temporary members for the specific research field under discussion.

PRESIDENT AND PRESIDENTIAL COMMITTEE

PRESIDENT

A full-time president heads the Helmholtz Association and represents it externally. He or she moderates the dialogue between science, industry and government and is responsible for preparing and implementing the Senate's recommendations regarding programme-oriented funding. The president coordinates programme development across research fields, cross-centre controlling and the formulation of the association's overarching strategy.

VICE-PRESIDENTS

The president is supported, advised and represented by eight vice-presidents. Six are scientific vice-presidents who coordinate the six research fields, while the other two represent the association's administrative arm.

MANAGING DIRECTOR

The managing director of the Helmholtz Association represents, advises and supports the president in fulfilling his or her duties and runs the association's head office. As a special officer for administrative matters, the managing director represents the Helmholtz Association both internally and externally.

The Helmholtz Association's Executive Committee is made up of the president, the eight vice-presidents and the managing director.

HEAD OFFICE

Together with the international offices in Brussels, Moscow and Beijing, the head office assists the president, the vice-presidents and the managing director in fulfilling their duties.

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

RESEARCH FIELDS

In the six research fields supported by programme-oriented funding, Helmholtz scientists carry out cross-centre research with external partners in interdisciplinary and international collaborations.

ASSEMBLY OF MEMBERS

The Helmholtz Association is a registered association comprising 17 legally independent research centres and one associate institute. Together with the Senate, the association's central body is the Assembly of Members, to which the scientific and administrative directors of each member centre belong. The Assembly of Members is responsible for all the tasks performed by the association. It defines the framework for the cross-centre development of both strategies and programmes and makes proposals regarding the election of the president and Senate members.

- Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research
- Deutsches Elektronen-Synchrotron DESY
- Forschungszentrum Jülich
- GEOMAR Helmholtz Centre for Ocean Research Kiel
- German Aerospace Center (DLR)
- German Cancer Research Center
- German Center for Neurodegenerative Diseases (DZNE)
- GSI Helmholtz Centre for Heavy Ion Research
- Helmholtz Centre for Environmental Research – UFZ
- Helmholtz Centre for Infection Research
- Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences
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- Karlsruhe Institute of Technology
- Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch
- Max Planck Institute for Plasma Physics (associate member)

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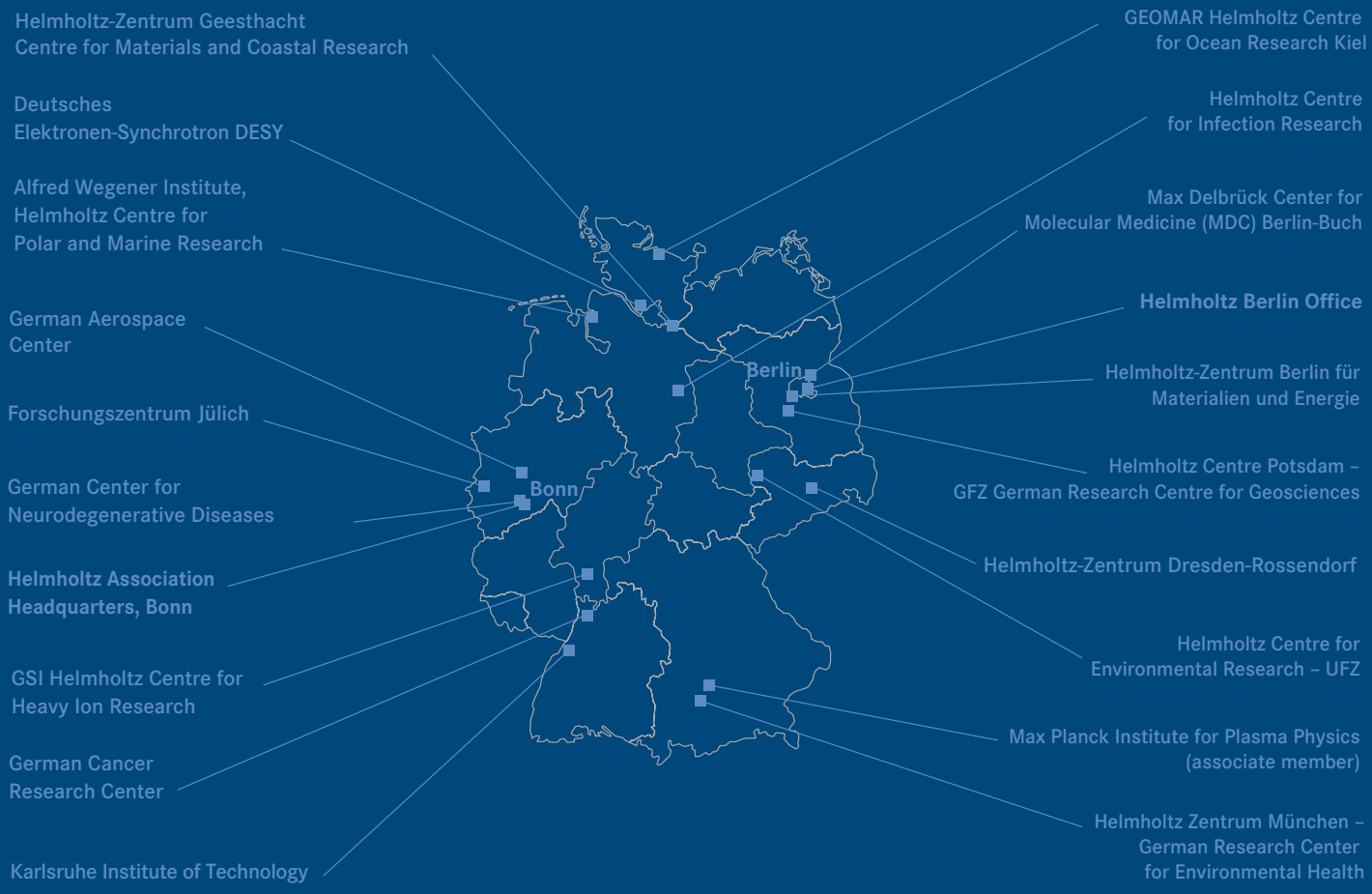

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