Research in Europe

Annual Report 2010

JÜLICH
FORSCHUNGSZENTRUM

Das Forschungszentrum Jülich auf einen Blick

Das Forschungszentrum Jülich betreibt interdisziplinäre Spitzenforschung und stellt sich drängenden Fragen der Gegenwart. Mit seiner besonderen Expertise in der Physik, den Materialwissenschaften, der Nanotechnologie und der Informationstechnologie sowie den Biowissenschaften und der Hirnforschung entwickelt es Schlüsseltechnologien für morgen. Damit leistet das Forschungszentrum Beiträge zur Lösung großer gesellschaftlicher Herausforderungen in den Bereichen Gesundheit, Energie und Umwelt sowie Informationstechnologie. Das Forschungszentrum Jülich geht neue Wege in strategischen Partnerschaften mit Hochschulen, Forschungseinrichtungen und der Industrie im In- und Ausland. Mit mehr als 4 700 Mitarbeiterinnen und Mitarbeitern gehört es als Mitglied der Helmholtz-Gemeinschaft zu den großen interdisziplinären Forschungszentren Europas.

Gründung
11. Dezember 1956
Gesellschafter
Bundesrepublik Deutschland (90 Prozent)
Land Nordrhein-Westfalen (10 Prozent)
Stammkapital 520 000 Euro
Budget
456 Millionen Euro
Fläche
2,2 Quadratkilometer

Mitarbeiterinnen und Mitarbeiter
(Stichtag 31.12.2010)

Gesamt	4 767
Darin enthalten:	
Wissenschaftler/ Wissenschaftlerinnen (davon Doktoranden/ Stipendiaten 443)	1 625
Technisches Personal	1 643
Auszubildende	298

Gastwissenschaftler
897 aus 45 Ländern

Vorstand
Prof. Dr. Achim Bachem (Vorsitzender)
Dr. Ulrich Krafft
(Stellvertretender Vorsitzender)
Prof. Dr. Sebastian M. Schmidt
(Mitglied des Vorstands)
Prof. Dr.-Ing. Harald Bolt
(Mitglied des Vorstands)

Wissenschaftlich-Technischer Rat
Prof. Dr. Ulrich Samm (Vorsitzender)

Aufsichtsrat
MinDirig Dr. Karl Eugen Huthmacher
(Vorsitzender)

Forschungszentrum Jülich at a Glance

Forschungszentrum Jülich pursues cutting-edge interdisciplinary research addressing the pressing issues of the present. With its special expertise in physics, materials science, nanotechnology and information technology as well as biosciences and brain research, it is developing key technologies for tomorrow. Forschungszentrum Jülich thus contributes to solving the grand challenges facing society in the fields of health, energy and environment, and information technology.
Forschungszentrum Jülich is also exploring new avenues in strategic partnerships with universities, research institutions and industry in Germany and abroad. With a staff of more than 4,700, Jülich – a member of the Helmholtz Association – is one of the large interdisciplinary research centres in Europe.

Founded
11 December 1956
Partners
Federal Republic of Germany (90%)
Federal State of North Rhine-Westphalia (10%)
Share capital € 520,000
Budget
€ 456 million
Area
2.2 km²

Staff

Total	4,767
Including:	
Scientists	1,625
(comprising PhD students/ scholarship holders 443)	
Technical staff	1,643
Trainees	298

(As of: 31.12.2010)

Visiting scientists
897 from 45 countries

Board of Directors
Prof. Dr. Achim Bachem (Chairman)
Dr. Ulrich Krafft (Vice-Chairman)
Prof. Dr. Sebastian M. Schmidt
(Member of the Board of Directors)
Prof. Dr.-Ing. Harald Bolt
(Member of the Board of Directors)

Scientific and Technical Council
Prof. Dr. Ulrich Samm (Chairman)

Supervisory Board
MinDirig Dr. Karl Eugen Huthmacher
(Chairman)

Annual Report 2010

Contents

Preface by the Board of Directors

"Europe needs outstanding European clusters with a worldwide appeal."

Taken from the federal government's High-Tech Strategy for Germany

Jülich does not just lie at the heart of Europe geographically. Thanks to its multifaceted networking with European partners and the creation of central research infrastructures, it is also actively involved in shaping the European research landscape. In an increasingly globalized world, today's grand challenges can only be solved by working together. Reorganizing energy supply in an environmentally friendly and climate-smart manner is but one example; another involves providing answers to pressing problems in the areas of health and information technology. Our mission, as we see it, is to create the basis for future key technologies, which will help us to achieve scientific and social progress in these fields – far beyond the boundaries of subject fields and nations.

Large research infrastructures play a decisive role in terms of maintaining Europe's ability to perform in the scientific and technological arena and in terms of improving our competitiveness on an international level. The Partnership for Advanced Computing in Europe (PRACE) is particularly important in this respect. PRACE comprises representatives from twenty European Member States, all of whom share the same aim: the creation of a European supercomputer infrastructure. Forschungszentrum Jülich contributes to PRACE in two ways: the current Council Chairman comes from Jülich and the Jülich Supercomputing Centre (JSC) brings its expertise to the table. Jülich is therefore a key player in the development of this partnership.

The European Strategy Forum on Research Infrastructures (ESFRI) has included PRACE in the European roadmap, which identifies new research infrastructures of European interest. The ESFRI project IAGOS, which explores the atmosphere, is coordinated by Forschungszentrum Jülich. Jülich researchers and science managers also contribute to other European projects, including the European Spallation Source (ESS) for neutron research and the FAIR accelerator facility. The central position held by Forschungszentrum Jülich in the European Research Area was further made clear by its involvement in 2010 in eleven large-scale projects, funded by the EU to a total of more than one million euros each, and its role coordinating a further seven EU projects.

Form follows function – what holds for good design is also important in science. Structures must correspond to the purpose for which they are intended. Research is a dynamic process, which means that the institutions involved in research must also adapt in response. For this reason, we overhauled our structures last year in Jülich and geared them towards new tasks.

The Board of Directors of Forschungszentrum Jülich: Prof. Dr. Achim Bachem, Dr. Ulrich Krafft, Prof. Dr. Sebastian M. Schmidt and Prof. Dr.-Ing. Harald Bolt (left to right)

Providing new energy technologies that are efficient, climate-smart and environmentally friendly is an aim that can only be achieved using a holistic, multidisciplinary research approach. In 2010, we decided to pool our expertise in this research field and bring the various elements together in the new Institute of Energy and Climate Research (IEK). The new IEK focuses on the development of energy conversion technologies which are clean, safe and do not waste resources, as well as on the question of how trace gas emissions influence our climate.

Forschungszentrum Jülich sees itself not only as playing a supporting role in the German science system, but also believes that it has a responsibility to shape and develop this system. In 2010, we therefore did not just set up the new Institute of Bio- and Geosciences (IBG) to focus Jülich research activities on the new priority area of bioeconomy, but we also initiated the Bioeconomy Science Center (BioSC), which is unique in Europe, as a structuring element in the German research scene. In addition to IBG, institutes from Heinrich Heine University Düsseldorf, RWTH Aachen University and the University of Bonn are also involved in BioSC. Currently, BioSC is home to 1,200 employees.

Further restructuring measures included the creation of the Peter Grünberg Institute (PGI), which pursues basic research in the field of electronic phenomena and systems, as well as the foundation of the Institute of Complex Systems (ICS), which investigates microscopic and molecular processes underlying both soft matter and living cells. The Jülich Centre for Neutron Science (JCNS), which operates instruments such as those at the FRM II research reactor, was also given the status of an independent institute in 2010.

Many of these key Jülich topics – from energy research and bioeconomy right up to information technology – are reflected in the forward-looking projects and lines of action in the German federal government's High-Tech Strategy 2020. Using numerous examples throughout this annual report, we explain how we hope to achieve these objectives in practice. As you read through the annual report, you will notice that the format has also changed. We have included even more facts and figures compared to last year in the form of tables and graphics. After all, strategically oriented research must be transparent to the general public. We have made progress in this area too during the course of 2010.

Prof. Dr. Achim Bachem
(Chairman of the Board of Directors)

Prof. Dr.-Ing. Harald Bolt
(Member of the Board of Directors)

Dr. Ulrich Krafft
(Vice-Chairman of the Board of Directors)

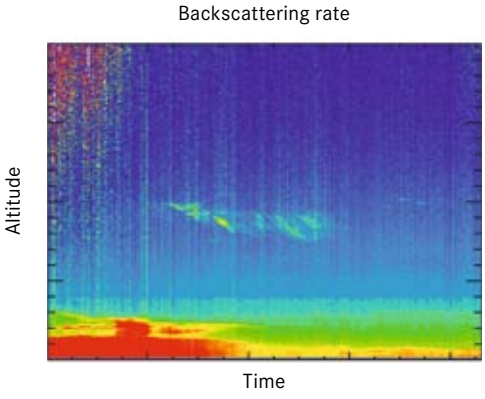
Prof. Dr. Sebastian M. Schmidt
(Member of the Board of Directors)

Chronology

April 2010 to March 2011

Calculating Elementary Forces

8 April 2010 | Scientists from Jülich and Bonn report in *Physical Review Letters* how they used a new method and the JUGENE supercomputer to reliably calculate the interactions in atomic nuclei – including those of lithium and carbon. In the past, this was impossible because the interplay of forces was too complex. The researchers now hope to use their calculation model to predict the properties of super-large nuclei that have yet to be discovered.

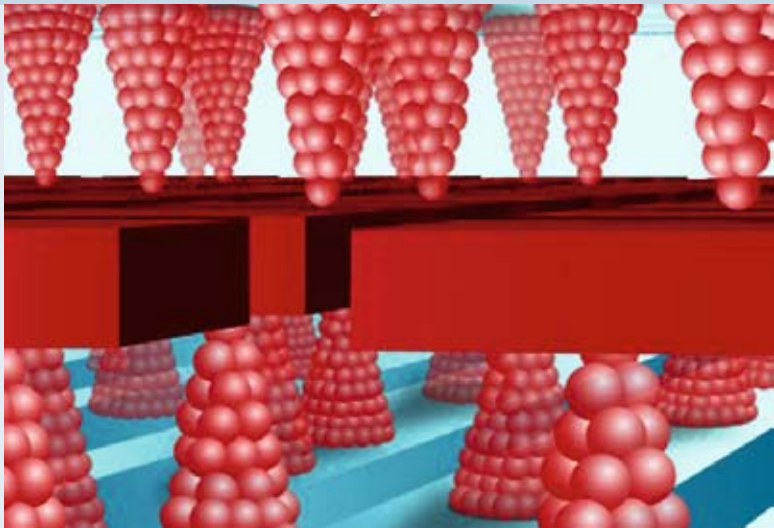


Measuring Volcanic Clouds

16 April 2010 | Jülich atmospheric researchers use a LIDAR system stationed at Forschungszentrum Jülich to measure the vertical expansion of the cloud of ash, which was spewed out by the Icelandic volcano Eyjafjallajökull as it erupted, obstructing European air space. LIDAR stands for light detection and ranging. The system sends a laser beam into the sky and the fraction of light that is reflected by the atmosphere is then analysed.

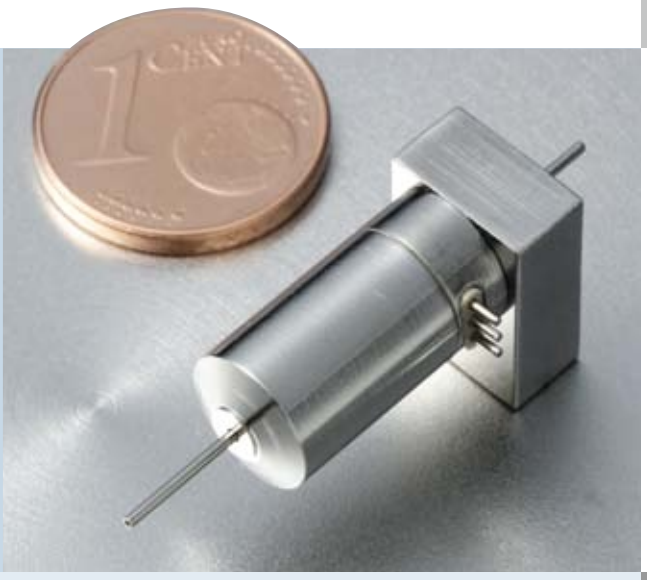
Energy-Efficient Computer Chips

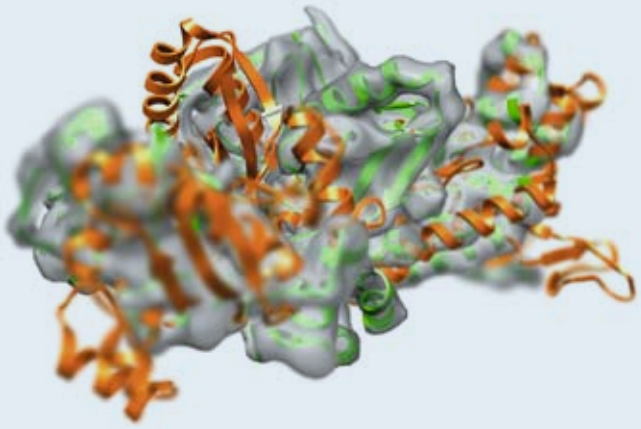
18 April 2010 | An article in *Nature Materials* by scientists in the Jülich Aachen Research Alliance (JARA) presents a new advantageous switching concept for memristor chips. The resistance of such chips can be programmed and subsequently remains stored. This paves the way for a new generation of computers, which will require less energy and simultaneously have a very high computing power.



Showcased by Industry

19 April 2010 | In research, being able to move objects measuring but a few nanometres in a controlled manner is becoming more and more important. A device capable of controlling the tip of a scanning probe microscope with an accuracy of one tenth of a nanometre (ten millionths of a millimetre) is presented by Forschungszentrum Jülich at the Hannover Messe, the largest industrial trade fair in the world. (More on this in “Using Knowledge”, p. 69). A fuel cell technology is also showcased which makes operating times of more than 20,000 hours (around three years) possible.





More Focused Insight into Proteins

22 April 2010 | Nowadays, professionals can touch up and digitally sharpen photos with low resolution. This is now also possible with blurred images that are sometimes produced by X-ray diffraction, making the spatial composition of protein molecules – important building blocks for all forms of life – visible. In *Nature*, Jülich researcher Gunnar Schröder and his US colleagues presented the newly developed method (see also “New Insights into Molecules”, p. 32).

Research School Officially Opened

28 April 2010 | Representatives from politics, industry and science officially open the new building of the German Research School for Simulation Sciences (GRS) on campus at Jülich. GRS is a joint venture between RWTH Aachen University and Forschungszentrum Jülich. It trains master’s and PhD students on the most state-of-the-art supercomputers in Europe.

World Hydrogen Energy Conference

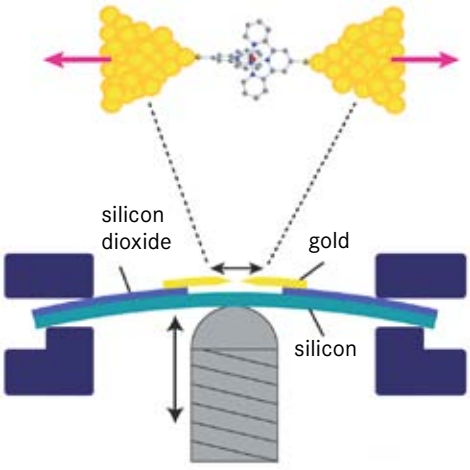
16–21 May 2010 | A total of 1,200 participants from fifty countries come to Essen for the World Hydrogen Energy Conference 2010 (WHEC 2010), chaired by Prof. Detlef Stolten of Forschungszentrum Jülich. WHEC 2010 focuses on the latest developments in hydrogen and fuel cell technology. Also on the agenda this year is a special day for the general public, in addition to special events for secondary school students and their teachers as well as undergraduates.

Uniting to Achieve a Factor of 1,000

31 May 2010 | Forschungszentrum Jülich, Intel and ParTec sign an agreement for a joint "ExaCluster Laboratory". The laboratory will develop modular computers (or clusters in the jargon) that will be capable of performing more than a quintillion arithmetic operations per second by 2020. This will make them 1,000 times faster than today's supercomputers.

Supercomputers for Europe

9 June 2010 | Representatives from nineteen nations attend the official event in Barcelona marking the beginning of the Partnership for Advanced Computing in Europe (PRACE). PRACE will provide supercomputers, infrastructures and the corresponding services for European researchers in the field of high-performance computing. Prof. Achim Bachem, Chairman of the Board of Directors of Forschungszentrum Jülich, was elected as the first Chairman of the Partnership.

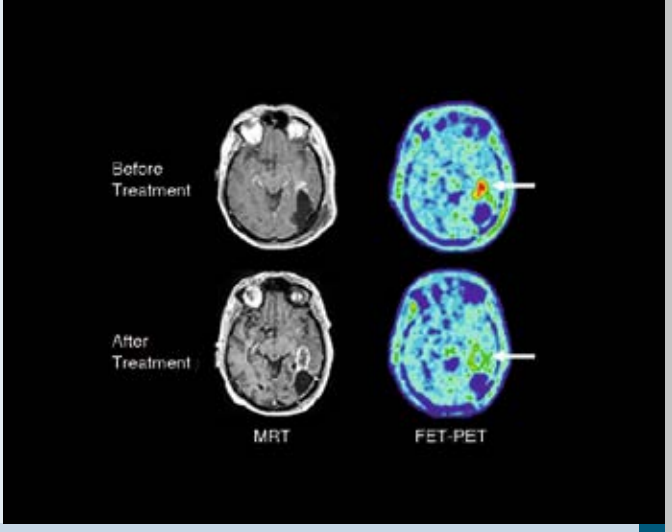


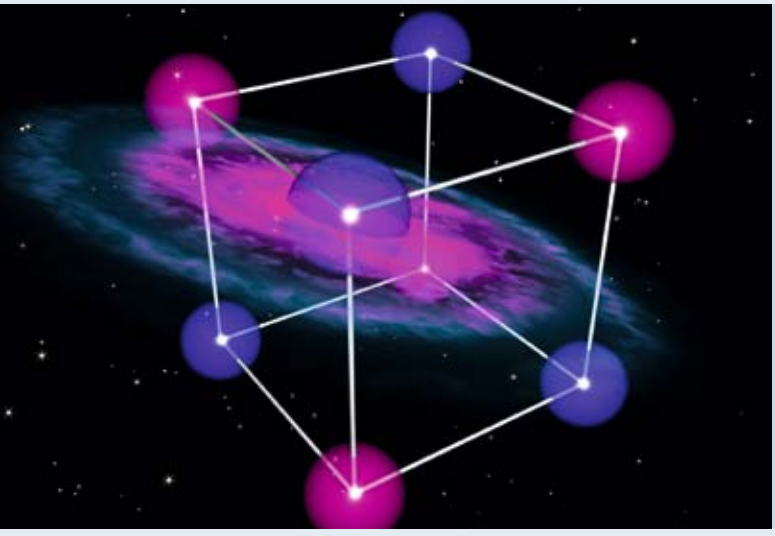
Manipulating Molecular Magnetism

11 June 2010 | Physicists from Jülich, the USA and Argentina publish an article in *Science* describing how the magnetic properties of individual molecules can be mechanically controlled. For the first time, the researchers confirmed the theoretical predictions of the "underscreened Kondo effect" in an experiment. This effect could become important in the future for information technology, making use of magnets the size of a nanometre.

Certainty Faster

21 June 2010 | How successfully a brain tumour has been treated can now be assessed seven to ten days after treatment – much faster than in the past. An innovative diagnostic technique known as FET-PET makes this possible. Scientists from the Jülich Aachen Research Alliance (JARA) report on the findings of a patient study in the *Journal of Radiation Oncology Biology Physics* (see also "Improved Assessment of the Effectiveness of Tumour Treatment", p. 65).



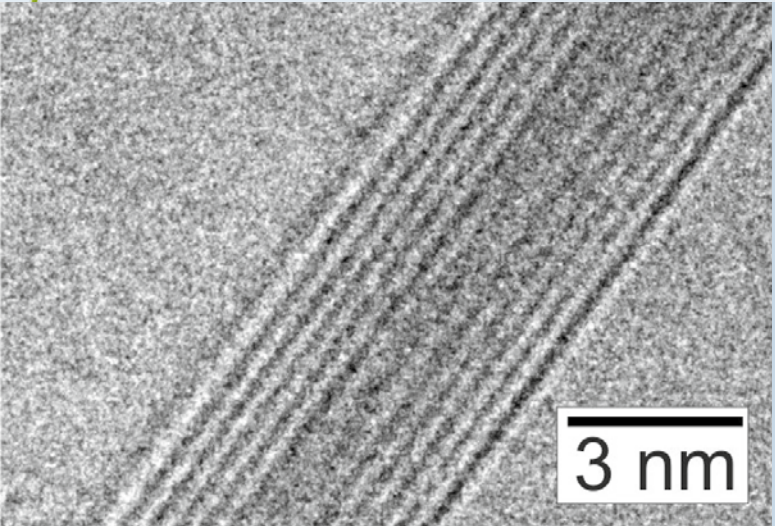


Designed with the Supercomputer

18 July 2010 | An international team that included Jülich researchers report on a new ceramic material in *Nature Materials*. The material's special properties were made to measure using the Jülich supercomputer JUROPA. The ceramic will help to clarify whether electrons also possess an electric dipole moment in addition to mass, charge and spin. Many theories of the world popular among physicists rest on this fourth property of electrons.

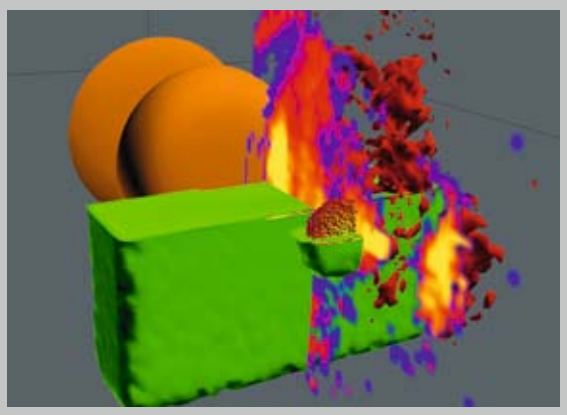
How Plants React

27 July 2010 | In *PNAS*, scientists from Jülich and the USA report on how the water balance in plants is controlled in a different manner than was previously assumed. Their assertion is based on experiments in which they investigated the reaction of sunflower leaves to infrared light, on the one hand, and visible light, on the other. According to their results, a direct biophysical process that is independent of photosynthesis and sensor cells controls the evaporation of water via closable pores, known as stomata, on the underside of the leaves.



Oscillating Nanotubes

3 October 2010 | Carbon nanotubes are regarded as a potential material for the information technology of the future. In *Nano Letters*, Jülich researchers present detailed investigations that help to tailor the mechanical properties of such tubes. The scientists compared the oscillating states of a nanotube with six walls to those of a single-walled carbon nanotube and found differences of almost twenty-five percent in the resonant frequencies.

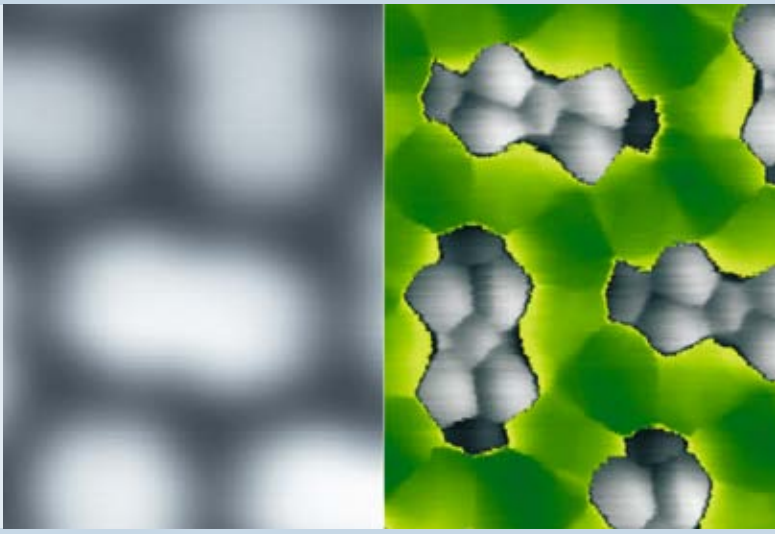


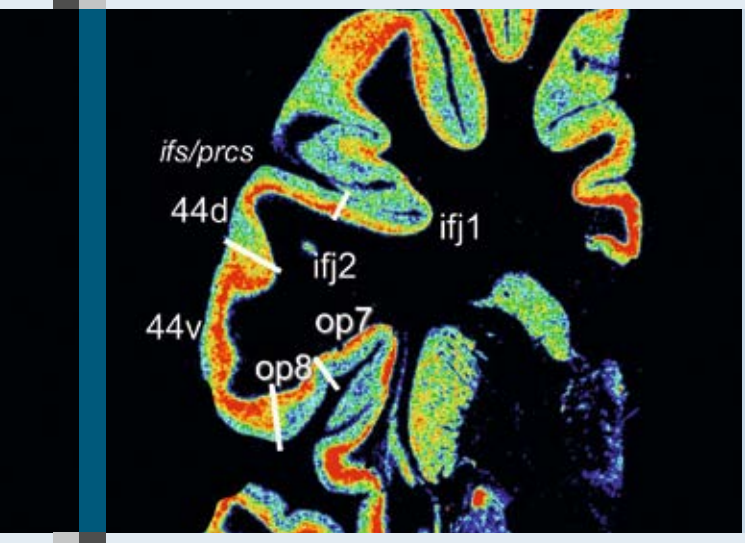
Compact Particle Accelerator

4 October 2010 | Researchers from Jülich and Belfast publish an article in *Physical Review Letters* presenting a compact alternative to large particle accelerators, which use electrical fields to accelerate protons to high speeds in kilometres of pipes. In simulations on the JUROPA supercomputer at Jülich, they created a stable proton beam by bombarding a plastic foil no thicker than a nanometre with a circular polarized beam of a pulsed laser.

Focused Insights into Molecules

6 October 2010 | "Where before only a blurred cloudy image was visible, the atomic details of the molecule now come into focus in high resolution." This is a translation of how the national newspaper *Frankfurter Allgemeine Zeitung* (FAZ) describes it. The new method made in Jülich employs hydrogen at the tip of a scanning tunnelling microscope, allowing us to look deep inside organic molecules (see also "New Insights into Molecules", p. 32).





Complex Brain

9 October 2010 | An article in FAZ reports on the results of Jülich research on speech. Researchers examined a brain region, which according to classic theory is responsible for the ability to form phonemes and words. They discovered that this region, known as Broca's region, does not just comprise two areas as previously believed, but rather many more (see also "More Complicated than Expected", p. 30).

Centre for Bioeconomy

21 October 2010 | The creation of the Bioeconomy Science Center represents the foundation of the first European centre that will pursue research for a sustainable bioeconomy in an integrated overall concept. Forschungszentrum Jülich will combine its expertise with that of the universities of Bonn, Düsseldorf and Aachen in order to contribute to an environmentally friendly economy based on renewable raw materials (see also, "Unique in Europe: The Bioeconomy Science Center", p. 62).

Important Plant Diversity

27 October 2010 | *Nature* publishes the findings of a large-scale study on biodiversity. Jülich scientists were involved in evaluating the results. In the eight-year field experiment over an area of four hectares, scientists investigated plots of grassland vegetation with a range of different plant species. It was found that even when only a single plant species becomes extinct, a wide variety of other life forms often die out with it, for example, herbivores and carnivores.

Construction Begins on Nanoelectronics Laboratory

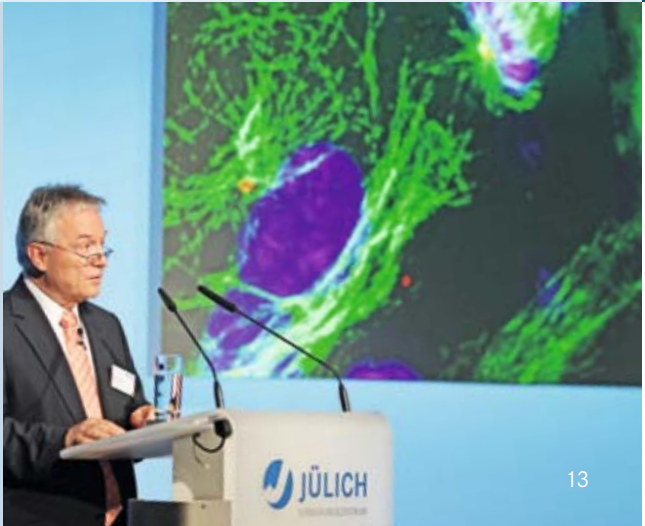
19 November 2010 | The first cut of the spade officially marks the beginning of construction for the Helmholtz Nanoelectronic Facility at Forschungszentrum Jülich. The modern clean room centre providing an area of around a thousand square metres will be completed by 2013. It will cost a total of approximately € 25 million. The laboratory is where the foundations will be laid for the electronics of the future.

Millions for Neutron Research

25 November 2010 | The Federal Ministry of Education and Research (BMBF) will support Jülich in the planning of the European Spallation Source with funding worth € 6.4 million. State Secretary Thomas Rachel presented the notification of approval to Prof. Sebastian M. Schmidt, who is a member of the Board of Directors at Jülich and also coordinates the German involvement in ESS. The most powerful neutron source in the world is to start operation in 2019 at Lund in Sweden.

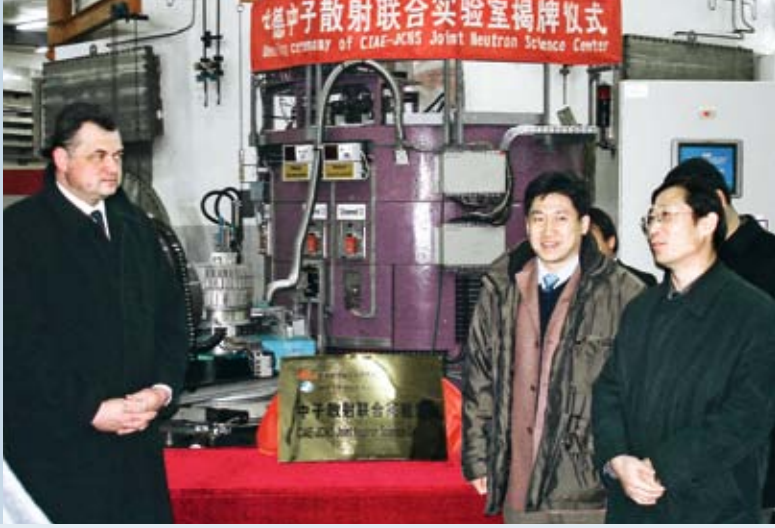
Official Insights

6 December 2010 | In his keynote speech marking the end of another year for Jülich at a function held in the Rhineland Regional Museum in Bonn, Prof. Dieter Richter provides politicians, managers and scientists with insights into the huge potential of neutron research. Among other things, it will help us to develop materials for computer storage systems of the future and for the generation of electricity from waste heat in motors. It will also help us to improve our understanding of biomolecular processes in cells.



Cooperation with China

13 December 2010 | Prof. Sebastian M. Schmidt, member of the Board of Directors, visits the CARR research reactor in Fang Shan near Beijing. Scientists from the Jülich Centre of Neutron Science (JCNS) installed three instruments there. In the future, they will also have access to this powerful neutron source for their experiments. Jülich already cooperates with numerous renowned Chinese research institutions (see also, “Knowledge Worldwide”, p. 54).

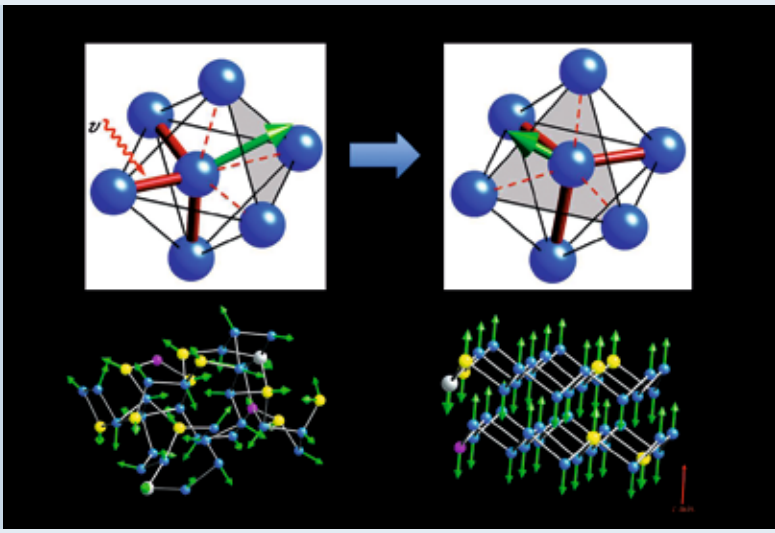


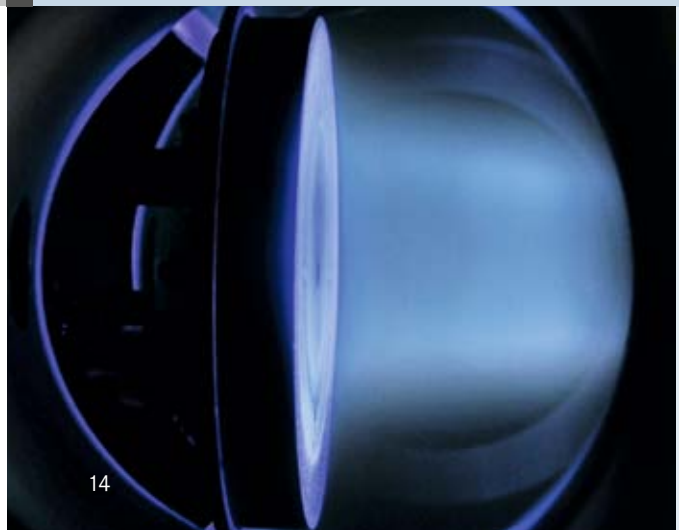
Fortifying Neutron Research

17 December 2010 | Forschungszentrum Jülich is to expand its range of instruments at the FRM II research reactor in Garching. It currently has five scientific instruments stationed there and intends to have eleven by 2013. Agreements were signed to this effect by representatives of three Helmholtz centres, the university of technology TU Munich, the Free State of Bavaria and the German federal government. In future, the Helmholtz Association centres involved will invest around € 30.3 million every year in neutron research. BMBF will also support the centres and the scientific infrastructure at FRM II with a further € 19.8 million every year.

Phase Change in DVDs

17 January 2011 | The computer technology magazine *c’t-magazin* reports on the findings of a group of scientists from Jülich, Finland and Japan who investigated the processes behind the writing of data to DVD-RWs. The team used simulations on the Jülich supercomputer JUGENE to explain the structure of two different phases of the DVD layer on which data is stored and to develop a model for the phase transition (see also “Super Research Thanks to Supercomputers”, p. 39).



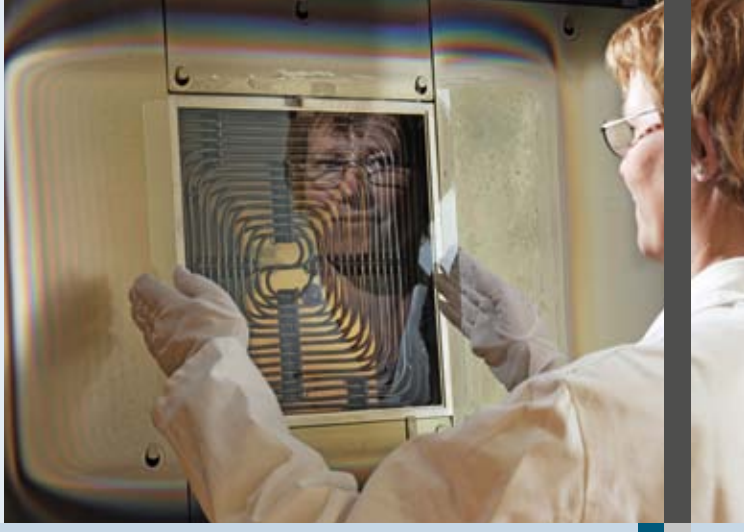


Fusion Research for 2035

15 February 2011 | The PSI-2 plasma generator goes into operation. The machine weighing three tonnes and costing € 1 million will be used to find materials that are capable of withstanding continuous operation as wall elements for use in a fusion power plant planned for 2035. The first wall of the combustion chamber must be able to continuously resist the strain placed on it by neutron bombardment and by the fusion plasma with a temperature of one hundred million degrees.

More Efficient Solar Modules

18 February 2011 | Solarserver.de and other Internet portals report on the LIMA research project, which has made it possible to fabricate the first silicon thin-film solar modules with an efficiency of ten percent and a surface area greater than one square metre. The industrial companies and research institutions involved succeeded in improving light management in the solar cells. The project was coordinated by Forschungszentrum Jülich.



Research in the Clouds

21 February 2011 | In Exeter in the United Kingdom, the Coalesc measurement campaign begins. Jülich researchers are cooperating with their British colleagues in order to find out how aerosols such as dust and soot influence cloud formation and precipitation. While the Coalesc flights are no higher than ten kilometres above the ground, the Macpex measurement campaign during the middle of March in Houston, Texas, will take us higher. Together with US partners, Jülich researchers will investigate processes in the cirrus clouds at an altitude of up to eighteen kilometres.

New Information on Bipolar Disorder

25 February 2011 | Stern.de, Ärzte-Zeitung.de and other online media report how an international team headed by scientists from Jülich, Bonn and Mannheim have discovered a genetic factor that increases the risk of bipolar disorder. The researchers have thus found a piece of the puzzle in understanding the origin of this common neuropsychiatric condition, which is also influenced by environmental factors.

Denser Data Storage

18 March 2011 | *Science* publishes a report by researchers from Jülich and Halle who studied a ferroelectric material with a high-resolution transmission electron microscope. The scientists directly observed for the first time that dipoles, which carry information in this material, can also organize in circular structures. This organization could make it possible to store data much more densely in future working memories.

Highlights

World-Class European Science

The European Union and its Associated Countries are more than just a large trade alliance. Together, they form a lively marketplace for exchanging excellent ideas from research and development – the driving forces behind progress.

Modern science may need brilliant brains but it also often needs complex structures and large instruments, which are either too expensive for a single country to purchase alone or which cost too much to operate and maintain. For this reason, the European Union supports the construction and operation of joint infrastructures, which should allow European researchers to pursue world-class research and safeguard future opportunities for generations to come.

Recommendations on infrastructures that are to be built and funded in Europe are made by the European Strategy Forum on Research Infrastructures (ESFRI). ESFRI is composed of experts from the Member States as well as representatives of the European Commission and is currently chaired by Dr. Beatrix Vierkorn-Rudolph (BMBF).

ESFRI was set up in 2002 by the European Commission. Since then, it has functioned as a platform for EU Member States to discuss and coordinate projects and trends in infrastructures for science and research. Examples include large-scale equipment, supercomputers and network architectures, as well as databases and virtual libraries.

In decision-making processes within Europe, ESFRI plays a key role. The European Council entrusted it with the development of a European roadmap for transnational infrastructure projects. The first list was drawn up in 2006, and since then, it has been revised every two years or so to reflect current conditions. Forty-four projects have been endorsed by ESFRI to date. Forschungszentrum Jülich is actively involved in many of these. With their know-how, Jülich researchers and science managers are helping to establish Europe as a leading location for excellent science, and thus helping to solve some of the pressing issues facing society.

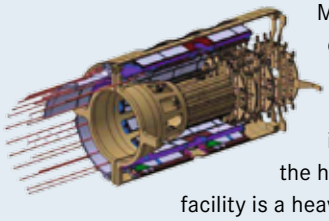
ICOS

Europe has an impressive measurement network both on land and at sea for processes that are relevant to the climate. ICOS aims to secure the existing network and to expand it over the next ten to twenty years in an effort to protect the climate. Only with the aid of reliable data, will we be able to assess the sensitive interaction between ecosystems and the atmosphere (see also p. 22)

ESS

On 28 May 2009, the decision was made in Brussels to build the European Spallation Source (ESS) in Lund in the south of Sweden. ESS will be open to scientists from all over the world who want to use neutrons to gain new insights into the composition of complex molecules and structures. In Europe alone, around 5,000 researchers from science and industry currently analyse their samples with neutrons. It is expected that this number will increase significantly when ESS goes into operation in 2019 (see also p. 21).

FAIR



More than a dozen countries are involved in FAIR. At the heart of the facility is a heavy ion ring accelerator with a circumference of a kilometre. The HESR storage ring for FAIR is being designed by Jülich. It will be 575 metres long and will help to make the planned experiments possible, for example those with antiprotons (PANDA). It will provide new information on the processes that take place between elementary particles, such as quarks and gluons. FAIR will be available for research in 2017 (see also p. 20).

Lund

Jülich

Darmstadt

Paris

IAGOS

Starting in 2012, up to twenty commercial airliners flying both within Europe and worldwide will be used for research. Highly sensitive measuring instruments will collect comprehensive data on the chemical and physical components of air. They will contribute to improving our understanding of the interactions in the atmosphere and help us to develop new approaches for climate protection (see also p. 22).

PRACE

For the PRACE project, twenty European countries joined forces in a unique initiative. It allows researchers from the countries involved access to high-performance computers in the other countries. In addition to the numerous high-performance computers, European scientists also have access through PRACE to JUGENE in Jülich and CURIE in Paris, which are currently the two fastest supercomputers for civilian use in Europe. Other supercomputers in Germany, France, Italy and Spain are due to follow by 2015 (see also p. 23).

Top Marks for Jülich Particle Physics

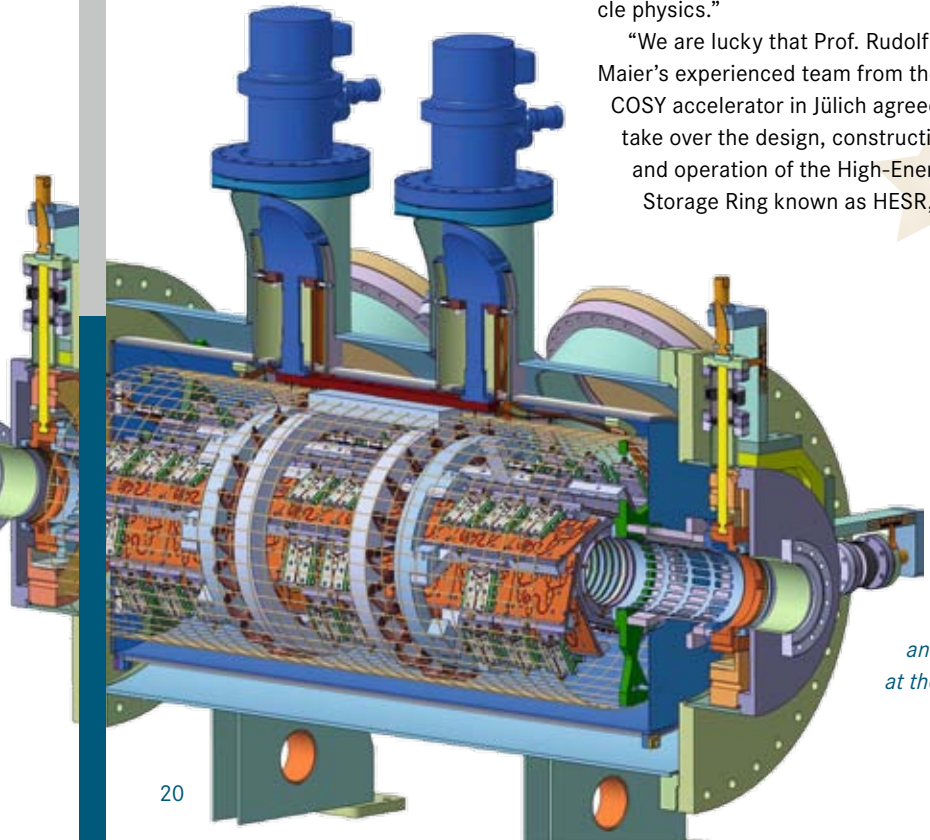
New insights into the structure of matter and the creation of the universe will be made possible by the international accelerator facility – FAIR – in Darmstadt. FAIR stands for Facility for Antiproton and Ion Research and is one of the largest research projects both in Europe and throughout the world. When it is finished, FAIR will comprise a total of two linear and eight ring accelerators. Physicists and engineers from Forschungszentrum Jülich are designing one of these – the High-Energy Storage Ring or HESR for short.

At the beginning of April 2011, rumours were rife in the press. Researchers from Fermilab in the USA had published data pointing to the discovery of a new basic building block or an as yet unknown interaction of matter. Scientists at the European Organization for Nuclear Research (CERN) in Geneva then began evaluating a flood of their own measurements in an attempt to either prove this discovery or refute it. "If the discovery made by Fermilab can be proven, then the principle behind it will have to be clarified. This discovery would in any case be of great benefit to the physics programme at HESR," says Prof. Rudolf Maier, director of the Nuclear Physics Institute at Jülich. Maier is also responsible for the design of HESR and for its research programme.

The international community of physicists have split the work. The fundamental building blocks of matter will be sought at the large accelerators, such as those at Fermilab or CERN. The smaller rings will be used by scientists to investigate how exactly matter is formed and what forces hold it together. "These are the main fields of research at HESR," says Maier. "HESR at FAIR could be described as the surgical scalpel of particle physics."

"We are lucky that Prof. Rudolf Maier's experienced team from the COSY accelerator in Jülich agreed to take over the design, construction and operation of the High-Energy Storage Ring known as HESR," says Dr. Horst Wenniger. The former director for technology at CERN brings his know-how to the table and is overseeing the construction of FAIR.

Wenniger emphasizes that all of the contributions made so far by Jülich to the HESR project, such as technical designs and calculations, have been evaluated with top marks by the international Machine Advisory Committee headed by Dr. Lyn Evans. "This is due to many years of experience and successful experiments at the COSY ring in Jülich," says Wenniger. He is certain that with their contributions to the FAIR project, Jülich researchers and engineers are creating unrivalled experimental conditions for a long-term research programme.



Engineers from Jülich's Central Technology Division (ZAT) are designing and building complex machines and detectors for HESR. This vacuum chamber is but one example. It concentrates the energy of the ion beam using high-frequency fields. Some of the key components and detectors are currently being tested and optimized at the COSY accelerator in Jülich.

ESS on the Home Straight

In the south of Sweden in Lund, a new large-scale facility is being built for scientists from all disciplines: the most powerful neutron source in the world – the European Spallation Source (ESS). Jülich researchers and science managers are actively involved in planning and designing the facility.

Some of the existing European neutron sources have been successfully operated for decades. They facilitate deep insights into matter – into materials for large constructions such as motors and components for space travel, as well as into the structure of tiny biological molecules and into complex entities such as plastics and hard disks.

This is made possible by neutrons, which are the uncharged components of atomic nuclei. They make structures smaller than a billionth of a metre and movements as fast as a billionth of a millisecond accessible. Neutron sources are used to generate free neutrons, which are then directed onto the specimens to be examined.

Today, some sources have reached their maximum lifetimes and will be shut down over the coming ten to twenty years. In the USA and Japan, new state-of-the-art neutron sources have therefore been built and have been in operation since 2006. ESS will be ready for operation in 2019, when it will be the most powerful spallation neutron source in the world.

ESS will particularly benefit from the experience gained by Jülich scientists working at the most powerful neutron source in the world today at Oak Ridge National Laboratory. Here, they operate an instrument known as a neutron spin echo spectrometer, or NSE for short, which is one of the best neutron instruments in the world. It provides us with insights into the movements of proteins and polymers and thus paves the way for innovative agents and materials.

The existing plans for ESS are currently being optimized and construction is due to begin in 2013. In this way, all central components will go through a fundamental design update. German researchers are putting their expertise to use in a collaborative project. In addition to Forschungszentrum Jülich, which coordinates the German activities, the Helmholtz centres in Berlin, Geesthacht and Dresden, the Karlsruhe Institute of Technology (KIT), DESY (the German electron synchrotron) and the university of technology TU Munich are involved.

The researchers are supported in their efforts by the Federal Ministry of Education and Research (BMBF). BMBF will provide them with a total of € 15 million. The partners themselves will invest a further € 6 million. “This huge investment shows just how attractive the ESS project is for science,” says Colin Carlile, Chief Executive and Director-General of ESS. “This contribution is more than welcome, particularly because neutron research has such a long tradition in Germany, and we want to build on this.”

Construction of the planned European Spallation Source in Lund. The ion source at the front of the picture generates the proton pulses, which can be accelerated to almost ninety percent of the speed of light. The round part of the building houses the target. It contains a heavy metal, such as lead or mercury. The collision between the protons and the metal atoms charges the atoms energetically, causing between twenty and thirty neutrons per atom to “vaporize”. These are then decelerated and directed onto the specimen to be examined. The inner structure of the sample material is then reconstructed based on the way in which the neutrons interact with the specimen being examined.

By Sea, Land and Air – Data for Climate Protection

In two unique projects, European researchers are constructing an extensive network of local and mobile measuring stations for climate research. With years of expertise and highly precise analytical techniques, Jülich scientists play a key role in the two collaborative research projects IAGOS and ICOS.

The objective is to identify events in the atmosphere and exchange processes between sea, soil and the air and to use this information to develop courses of action for climate protection. IAGOS is short for In-service Aircraft for a Global Observing System. The measuring instruments of this infrastructure coordinated by Jülich will be carried on board commercial airliners starting in 2012. They will track ozone and its precursors, for example, measure carbon dioxide (CO_2), carbon monoxide and nitrogen oxides, analyse particulates and cloud particles, and monitor the water vapour content of the atmosphere. According to Prof. Dr. Guy Brasseur, director of the Climate Service Center (CSC) at Helmholtz-Zentrum Geesthacht, "IAGOS benefits from the some fifteen years of experience obtained by our colleagues in Jülich, Germany and France. They have already proven the technical feasibility and safety of the systems during the previous projects MOZAIC and CARIBIC. The results show how valuable these data are for science and thus also for climate protection." He is convinced that IAGOS, as a globally unique observation system, will help us to gain a better understanding of the interactions and chemical processes in the atmosphere.

ICOS is the earth-bound and sea-bound equivalent to IAGOS. ICOS stands for Integrated Carbon Observation System. The project aims to identify the sources and sinks for carbon dioxide and other greenhouse gases in detail, both in Europe and beyond, over the next few decades. The researchers also want to find out how this cycle is influenced by changes in land use or by the climate changes that have already begun.

"Jülich expertise on soil moisture dynamics and the gas exchange between the atmosphere and different land use forms is an essential component in ICOS. ICOS also profits from infrastructures already in place, for example, TERENO*. The two long-term monitoring platforms complement each other perfectly," says Dr. Werner Kutsch, coordinator of the German activities in ICOS. Kutsch is a specialist for trace gas fluxes between ecosystems and the atmosphere at the Johann Heinrich von Thünen Institute in Braunschweig.

In addition to measuring stations on land, analytical devices will also be installed on board ships. In the past, the sea was regarded as a large CO_2 sink and hope was thus attached to it for climate protection. Recent measurement data, however, suggest that the ability of the ocean to adsorb the climate-damaging CO_2 is rapidly decreasing.

The soil is where a large proportion of bound carbon is stored. Global estimates are somewhere around 1,600 billion tonnes. In order to ascertain how fast it is transformed and released back into the atmosphere as CO_2, Jülich researchers monitor changes in soil using different methods – for example, under the surface with probes and lysimeters or above the surface with radiometers.

*TERENO is a network of measuring stations that stretches across the whole of Germany – from the plains in the north of Germany as far as the Bavarian Alps. In addition to climate data, observations on water and soil quality, vegetation and on biodiversity are being continuously recorded and analysed on a time scale of at least fifteen years.

PRACE – High Performance for Europe

In spring 2010, Germany and nineteen other European Member States established the Partnership for Advanced Computing in Europe (PRACE). This European research infrastructure for high-performance computing offers world-class services and resources. All European scientists, regardless of where they are or the capacities of their own research institution, thus have access to the key technology of supercomputing. Researchers and science managers from Jülich are the architects of this unique infrastructure.

High-performance computers have become an indispensable tool for science and industry. Material properties, environmental forecasts, aircraft development or insights into protein structures – simulations on high-performance supercomputers and highly specialized programmers can address issues that experiment and theory cannot. As a new European research infrastructure, PRACE pursues a number of objectives. It aims to safeguard Europe as a location for science and industry, to train outstanding simulation experts, and it endeavours to develop energy-saving, powerful and faster computer systems as well as a stable and secure European network for data transfer.

Jülich is where the various elements of this European supercomputing network converge. Catherine Rivière, director of the French organization for high-performance computing GENCI (Grand Equipement National de Calcul Intensif), refers to the central role played by Jülich. “With its dynamics and energy, Jülich project management is a key factor in the success of PRACE.” She emphasizes how important the specialized know-how of the participants is: “The Jülich team has in-depth technological expertise with regard to high-performance computing. This contributes a great deal to the quality of our work.” After all, PRACE is not just about dividing up computing time. The best simulation and computer researchers make use of PRACE and take computing time and numerical values as a basis to create new insights and solutions for industry and science that also benefit society. In this way, supercomputers can be used, for example, to improve safety at large public events by optimizing escape routes and improving the deployment of emergency services. The high computing power also allows researchers to clarify how swine flu viruses spread and to design the architecture of a pioneering quantum computer.


760561 874346 508221
593 782729 774332
448692 212350
872992
250670 710562
TMR
970278 447894 656439 569339
522017 602448 262792

Knowledge Management

Our Business: Knowledge

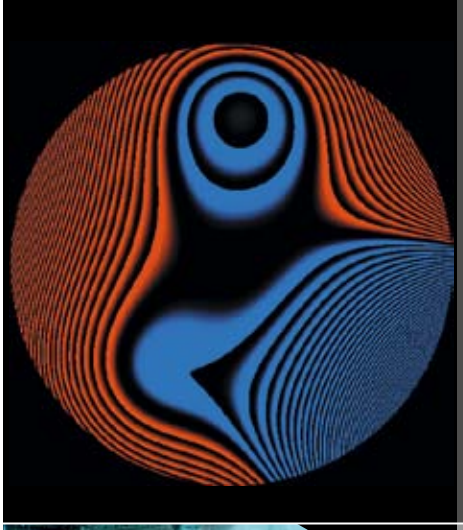
Knowledge is a valuable commodity. The prosperity and well-being of our society depends upon researchers finding ways of solving the key challenges of today. Energy supply must be restructured and made more sustainable, climate change must be restricted, and a population with a longer life expectancy must be kept healthy. Forschungszentrum Jülich is working on these areas in cooperation with partners from science and industry.

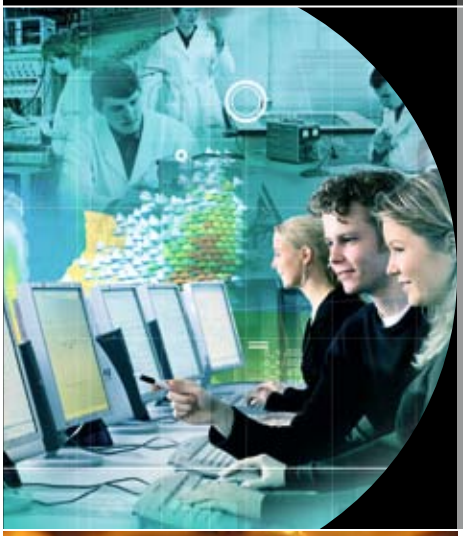
Creating knowledge, imparting it, sharing it and using it – these are the elements of effective knowledge management at Forschungszentrum Jülich. They involve strategically oriented cutting-edge research, a huge commitment to train and support early-career scientists, varied and intensive collaboration with scientific institutions both at home and abroad, and close cooperation with companies in order to put new knowledge to use in practical applications.

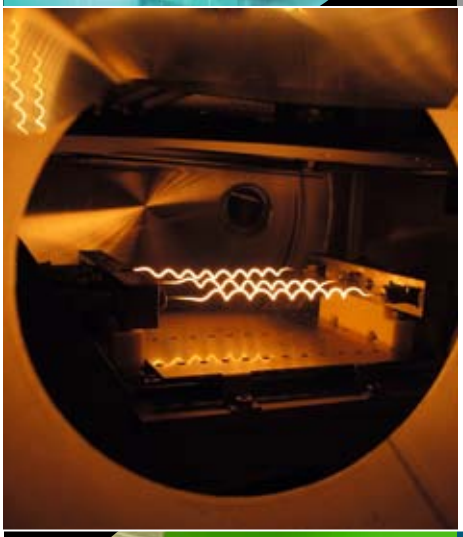
Creating knowledge

The achievements of Forschungszentrum Jülich in the area of research are highly acclaimed within the scientific community and beyond. No matter what benchmark we take – Jülich's performance was outstanding once again in 2010. Jülich scientists published almost 1,000 scientific papers in high-impact specialist journals and they were extremely successful in acquiring third-party funds. Take funding granted to Jülich scientists by the German Research Foundation (DFG) as an example: compared to the last few years, this funding increased substantially once again, rising to more than € 36 million. In 2010, Jülich energy research proved to be particularly attractive to third parties, which is good news considering how central this research is to our future.

The leading position held by Forschungszentrum Jülich is first and foremost due to the achievements of its employees. Jülich provides them with a unique research infrastructure – for example, with access to supercomputers in the Jülich Supercomputing Centre or to COSY, the accelerator and storage ring. They also benefit from excellent working conditions, which include mentoring programmes for women in executive positions as well as measures implemented by Forschungszentrum Jülich to reconcile research and family life. Jülich's continuing progress in this area was recognized in August 2010, when it became "berufundfamilie" certified after an audit that concluded it was "family friendly".







Imparting knowledge

Trainees, PhD students, and early-career scientists – these are the people who will take the knowledge that they gain today, bring it with them into the future, and use it to create something new. Forschungszentrum Jülich can look back with pride at the last fifty years during which young people qualified for a variety of professions – starting with the first trainee back in 1961 and stretching right up to today, when many young people now avail of the opportunity to combine their vocational training with university studies. The development of such dual study programmes was furthered over the past few years by Forschungszentrum Jülich.

Together with partner universities, Jülich offers graduates the best possible conditions for them to launch their scientific careers – from graduate schools funded by the Excellence Initiative to numerous other research training groups. The latest addition is Helmholtz Interdisciplinary Doctoral Training in Energy and Climate (HITEC), which came into being in spring 2011. In cooperation with five partner universities, and thanks to € 2.4 million of funding from the Helmholtz Association, around 225 PhD students are being trained in HITEC as energy and climate experts.

Sharing knowledge

Sharing knowledge will not make a person poorer; instead it will help them to win cooperation partners who can then put their expertise to use in collaborative projects. Forschungszentrum Jülich works with a variety of national and international partners from science and industry, and has assumed a leading position in Europe. In 2010, it was involved in eleven large-scale EU projects (each with funding in excess of one million euros). Seven EU projects were coordinated by Jülich. On a national level, participation in a dozen collaborative research centres reflects how closely Forschungszentrum Jülich networks with other research institutions and universities. The excellent progress being made by the Jülich Aachen Research Alliance (JARA), for example, is revealed in the steadily growing number of joint appointments of professors at RWTH Aachen University and Forschungszentrum Jülich.

Many more than 300 national and international collaborations with partners in industry testify to the combination at Jülich of long-term, knowledge-oriented research with practical technological developments and innovative application prospects.

Using knowledge

Jülich's know-how in decisive research fields, such as nanotechnology, and its outstanding infrastructure and expertise in key technologies make Forschungszentrum Jülich a much sought-after partner in industry. Whether it's the development of analytical techniques for atmospheric research, the transition from microelectronics to nanoelectronics, or the investigation of efficient methods for energy conversion – scientists at Forschungszentrum Jülich are working with large, medium and small enterprises in many application-oriented fields of research. They hope to find solutions to the problems facing us today and those that will arise tomorrow, and to ensure that these solutions can be technically and economically implemented.

Achieving and Publishing New Insights

When scientists achieve new insights by means of their research, they share this new knowledge with their colleagues in specialist journals. Scientific publications are therefore the most important demonstration by a scientist or scientific institution of their achievements. By publishing, researchers are continuously expanding the pool of knowledge, which is then used by other scientists in their work.

● Jülich publications in the last four years

	Total	In peer-reviewed journals (including those co-authored with researchers from other institutions)	Books, other publications	PhD theses, habilitiations
2007	1,907	1,141 (810 = 71.0 %)	695	71
2008	1,725	1,034 (753 = 72.8 %)	600	91
2009	1,720	1,133 (837 = 73.9 %)	526	61
2010	1,834	1,048 (770 = 73.5 %)	686	100

● The journals in which Jülich researchers published most frequently in 2010

Impact factors are a measure of how the specialist community regards a journal. The higher the value, the higher the impact. The factors indicate how frequently the articles published in two volumes of a journal are cited on average in the subsequent year by other publications.

Journal	Number of publications	Impact factor
Physical Review B	50	3.475
Geophysical Research Abstracts	46	No data
Physical Review Letters	37	7.328
Atmospheric Chemistry and Physics	25	4.881
NeuroImage	20	5.739
Applied Physics Letters	16	3.554
Journal of Applied Physics	16	2.072
Nature	5	34.480
Science	1	29.747

● Exemplary Publications 2010

Topic	Journal	DOI	Further Information
Interactions in atomic nuclei	Physical Review Letters 2010, 104, 142501	10.1103/ PhysRev Lett. 104.142501	Chronology, p. 8
Energy-efficient computer chips	Nature Materials 2010, 9, 402-406	10.1038/ nmat2748	Chronology, p. 8
X-ray structural analysis of protein crystals	Nature 2010, 464,1218-2222	10.1038/nature08892	New Insights into Molecules, p. 32
Mechanically controlling the magnetism of individual molecules	Science 2010, 328, 1370-1373	10.1126/ science. 1186874	Chronology, p. 10
Oscillating states of multi-walled carbon nanotubes	Nano Letters 2010, 10, 4470-4474	10.1021/ nl102305a	Chronology, p. 11
New methods of scanning tunnelling microscopy	Physical Review Letters 2010, 105, 086103	10.1103/ PhysRev Lett. 105.086103	New Insights into Molecules, p. 32
Structure of Broca's region in the brain	PLoS Biol 8(9): e1000489	10.1371/ journal. pbio. 1000489	More Complicated than Expected, p. 30
Computer simulations of the binding behaviour of peptides on the surfaces of solids	Angewandte Chemie 2010, 122, 9721-9724	10.1002/ ange. 20100098	Super Research Thanks to Supercomputers, p. 39

More Complicated than Expected – Language Regions in the Human Brain

New findings on a well-known structure of the brain were published by Prof. Katrin Amunts and her team in the well-respected specialist journal *PLoS Biology*. They discovered that one of our language centres – Broca's region – is much more complex than was previously assumed.

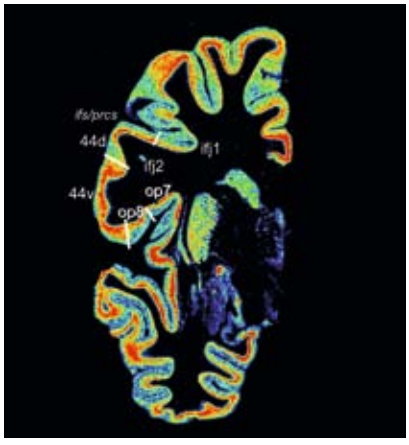
If you watch how a young child learns how to speak or if you are learning a foreign language yourself, then you will be only too well aware of how complex language is. Using words correctly and pronouncing them properly, applying the rules of grammar and appropriate intonation, even forming rhymes and complex sentences – all of these tasks demand a high level of performance from the brain.

This performance is made possible by structures which have been analysed for the first time on a molecular level by Katrin Amunts and her colleagues at the Institute of Neuroscience and Medicine. The head of Human Brain Mapping took a closer look at the area in the brain known as Broca's region. In the middle of the 19th century, it was discovered that this region is essential for speech.

In 1861, the physician Paul Broca reported on a patient who could understand what was said but could only say the word "tan" himself. As a region in the left cerebral hemisphere of this patient had been damaged after a stroke, Broca assumed that the speech centre must be located here. And only in the left hemisphere because the same spot on the right-hand side was not damaged. From then on, this region was known as Broca's region and was regarded as the motor language centre. "It was an important discovery that mental performance could be related to a certain brain region," says Amunts. "Today, we know that we must break things down even further: Broca's region comprises several areas that can also be functionally differentiated on a molecular level." Furthermore, her working group identified many other brain areas right beside Broca's region which are also involved in the production and control of language.

Amunts came across this varied brain landscape while examining the distribution of molecules in the brain via which the neurons communicate with each other. Information is passed from cell to cell by different neurotransmitters. The neurotransmitter can only be delivered if the neuron possesses an appropriate receptor molecule to which the respective neurotransmitter can couple. The Jülich researchers labelled six different types of receptors in thin sections of the brains of deceased individuals. In doing so, they discovered that these were not at all equally distributed. "And when areas differ in terms of the distribution of different types of receptors, then it's safe to say that they have different functions," says Amunts.

This relationship becomes clear if we look at the receptor for the neurotransmitter acetylcholine as an example. It is found on the left of the brain in a section of Broca's region in a very high concentration, while it is present in much lower concentrations in the corresponding section in the right hemisphere. Such



The distribution of different receptors in the brain (receptor architecture) provides us with insights into the functional and molecular principles of organization in the brain, as receptors play a key role in signal transduction between neurons (and, as we know today, also between neurons and glial cells). The image shows a cross-section of a hemisphere of the brain in a region that is important for language. The concentrations of a receptor for the neurotransmitter glutamate are shown in colour – the redder the colour, the higher the concentration of the neurotransmitter, the bluer the colour, the lower the concentration. Areas 44d and 44v are part of Broca's region.

Prof. Katrin Amunts analysed the distribution of receptors in the brain and in doing so discovered that Broca's language centre is much more complex than was previously assumed.

differences can help us to understand why the left hemisphere is language dominant in approximately ninety-five percent of the human population. When the left Broca's region has been damaged by a stroke, for example, speech is affected. However, damage to the corresponding structure in the right hemisphere has little or no effect on speech flow.

The distribution pattern of receptors showed that Broca's language centre comprises several areas forming a highly differentiated mosaic. This is how Prof. Karl Zilles, who was also involved in the study, summarizes it. A highly complex structure in the brain is therefore responsible for the multitude of language functions. "We don't yet know which mosaic pieces are responsible for which functions," says Amunts. This will have to be investigated in the future in healthy individuals and in patients undergoing treatment by means of functional imaging techniques. These techniques show which areas of the brain are active during different tasks.

Katrin Amunts and her team are already analysing another brain region: Wernicke's area. According to text books, this area is involved in understanding language. However, we can also assume here that the relationship between structure and function is much more complicated than was previously assumed. The long-term objective of Jülich brain researchers is to create a three-dimensional brain atlas with a previously unrivalled precision showing how the network of interacting nodes in the brain is structured.

The neurobiological insights are important in medicine, for example to understand the consequences of stroke or for certain neurodegenerative diseases. They also provide us with promising findings for language teaching. "The complex structures in Broca's region develop right up into late puberty," says Amunts. "Further developing linguistic abilities in teenagers who were not optimally encouraged during early childhood is therefore also promising."

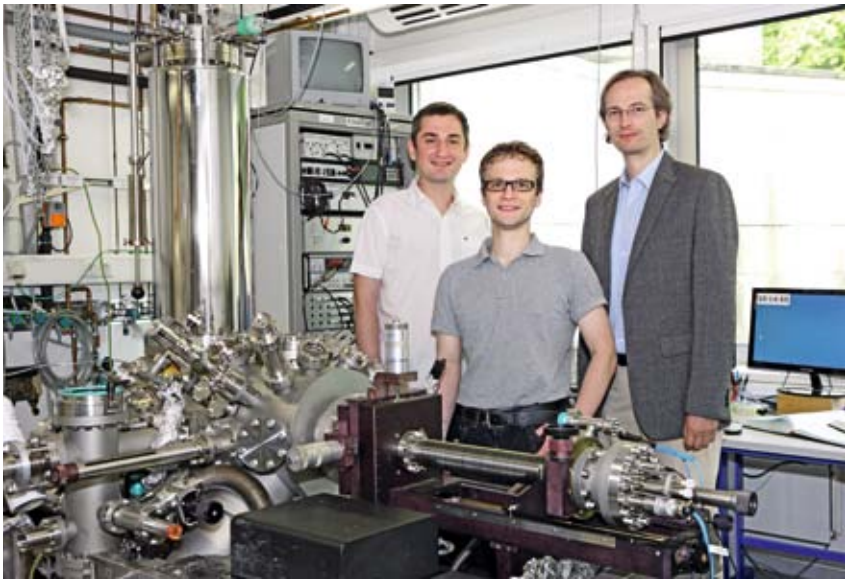
New Insights into Molecules

An important measure of the quality of a photographic objective or of a camera sensor, for example, is resolution. It indicates the capability of instruments to reproduce the finest of structures. How the resolution of a scanning tunnelling microscope can be significantly improved was described in *Physical Review Letters* by Prof. Stefan Tautz's team at Jülich. The publication simultaneously caused a stir among the specialist community. Another Jülich scientist, Dr. Gunnar Schröder, presented a method together with US scientists in *Nature* that allows the images of protein molecules, for which only low resolution X-ray diffraction data exist, to be "touched up" and sharpened.

The invention of the scanning tunnelling microscope in 1981 paved the way for nanotechnology, which enables us to change and use structures and components smaller than a hundred nanometres (one nanometre is a millionth of a millimetre). The scanning tunnelling microscope makes individual atoms visible and allows us to investigate them. Its thin metal tip travels over the surface of a material just like the needle of a record player and uses minuscule electric currents to register atomic irregularities and differences. However, atomic structures inside organic molecules remained invisible for a long time despite this technique.

In 2008, Prof. Stefan Tautz, Dr. Ruslan Temirov and scientists from the former Institute of Bio- and Nanosystems (today Peter Grünberg Institute) created the first images using a scanning tunnelling microscope of flat organic molecules showing much more detail than usual. Up to then, a molecule knows as PTCDA for short, comprising seven connected rings of carbon and oxygen atoms, for example, was only visible as a large spot around a nanometre in size. The Jülich images, on the other hand, showed the honeycombed inner structure formed by the rings.

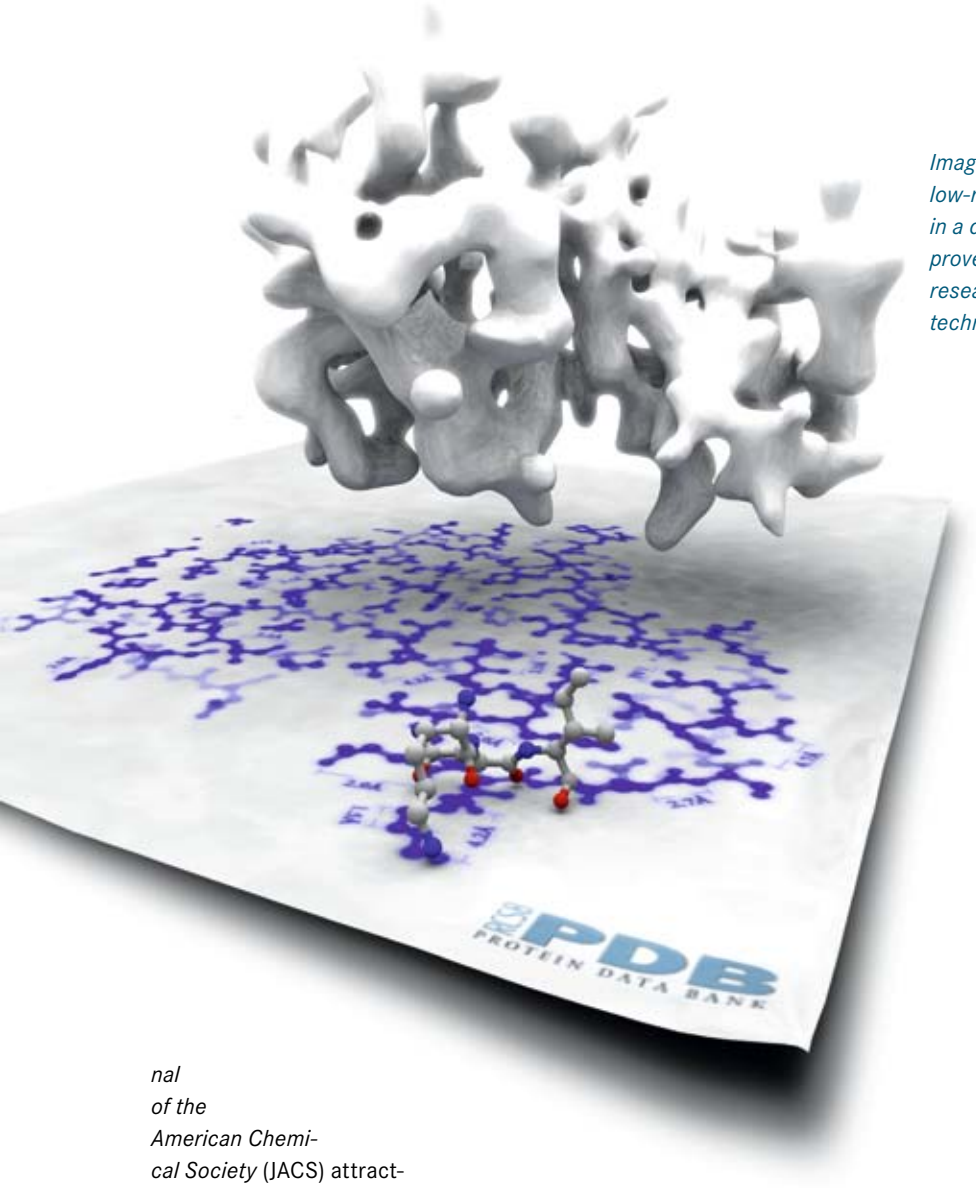
Dr. Ruslan Temirov (left), Christian Weiss (middle) and Prof. Stefan Tautz discovered how the inner structure of organic molecules can be made visible with the scanning tunnelling microscope.



Hydrogen as a sensor

The trick behind this involves introducing hydrogen or deuterium (also known as heavy hydrogen) into the vacuum chamber of the microscope. A hydrogen molecule then attaches to the tip of the microscope, traces the contours of the specimen surface and influences the currents that flow over the tip of the microscope. In 2010, Jülich scientists published new findings, which were also facilitated by computer-aided calculations performed by a working group at the University of Osnabruck. According to these findings, the principle behind the method is Pauli repulsion. This is a quantum-physical force that acts between the hydrogen or deuterium and the respective organic molecule. "The hydrogen or deuterium molecule takes on the function of a sensor and signal transducer," says Tautz.

The publication of these findings in *Physical Review Letters* and in the *Jour-*



Images of the structure of proteins, for which low-resolution measurement data are available in a database, can usually be significantly improved using a new computing technique. Jülich researcher Gunner Schröder developed this technique in cooperation with two US scientists.

nal of the American Chemical Society (JACS) attracted attention in the specialist community. For example, *Nature Physics* and *Nature Chemistry* reported on it; *Nature Nanotechnology* even referred to the result at Jülich as a "research highlight". In an article in *Chemistry World*, experts outlined possible applications of the new method. It can be used, for example, to measure the structure and charge distribution of flat molecules which may function as organic semiconductors or as part of future electronic components. The Jülich researchers have since filed a patent for their technique. "It's the remarkable simplicity of the method that makes it so valuable for future research," says Tautz.

Better "X-ray images" of proteins

When it comes to analysing the atomic structure of protein molecules, scientists often turn to a technique known as X-ray structural analysis. This involves using crystals of the protein and it exploits the fact that X-rays are deflected – or diffracted in the jargon – on the atoms of the crystal lattice. The difficulty here is that particularly the large protein molecules comprising several thousand amino acids are very flexible in their spatial distribution in the crystal. This explains why the diffracted X-rays only provide a blurred picture as it were of the spatial structure of the protein. Jülich scientist Gunnar Schröder and two US scientists developed a method to sharpen this image.

A correct and precise idea of the configuration and spatial arrangement of proteins is hugely important in order to understand the processes that take place in living things. We know that even the tiniest of defects in the atomic architecture of a protein molecule can affect the cells' function and lead to problems such as Alzheimer's disease.

"The task of producing a high-quality image of the protein structure from the measurement data is a highly complex search problem," says Schröder. The head of a young investigators group at the Jülich Institute of Complex Systems continues, "In order to direct the computer-aided search in the right direction, we also consider high-resolution information on similar proteins." As the scientists reported in *Nature*, they used this technique to significantly improve most of the images of the structure of nineteen proteins, for which low-resolution measurement data were saved in a protein database. They have since incorporated their method into the CNS computer program, which is used throughout the world by universities and research institutions for crystal structure analysis. A US research group, for example, has already underlined in the well-respected specialist journal *Cell* how important the Jülich technique was for them in successfully clarifying the structure of the protein kinase CβII.

Awards

Prof. Dr. David DiVincenzo from the Peter Grünberg Institute was awarded an Alexander von Humboldt Professorship, which includes funding worth € 3.5 million provided by the Federal Ministry of Education and Research (BMBF). This is the most lucrative international research prize in Germany and is intended to attract the most globally sought-after scientists to Germany for long-term research work. DiVincenzo accepted the newly established Jülich Aachen Research Alliance (JARA) professorship and simultaneously became head of the newly founded Institute of Theoretical Quantum Information at RWTH Aachen University and director of the Institute of Theoretical Nanoelectronics at Forschungszentrum Jülich.

Prof. Dr. Ulf-G. Meißner from the Nuclear Physics Institute was appointed Fellow of the Council of the American Physical Society. The society paid tribute to Meißner's outstanding achievements in physics. The number of fellows is limited to half a percent of the total number of members.

Meißner was also elected member of Academia Europaea. Academia Europaea was set up in 1988 with the objective of promoting education and research in Europe and of strengthening interdisciplinary and international research in all areas of learning. Currently, it has 2,300 members.

Prof. Dr. Dr. Peter Tass from the Institute of Neuroscience and Medicine and Dr. Wassilios Meißner, neurologist at the University of Bordeaux, received the Rapid Response Innovation Award for the second time in succession in recognition of their joint studies on Parkinsonian primates. The prize is awarded by the Michael J. Fox Foundation (MJFF) to research work with the potential to improve treatment for patients with Parkinson's disease within a few years. A clinical study headed by Tass was also successfully conducted in 2010 on treating tinnitus with the Jülich neurostimulator. The neurostimulator was developed by Forschungszentrum Jülich's licensing partner ANM Adaptive Neuromodulation GmbH and has been approved for use as a medical product.

Prof. Dr. Knut Urban from the Peter Grünberg Institute was jointly awarded the coveted Wolf Prize for Physics together with Prof. Dr. Maximilian Haider from CEOS GmbH, Heidelberg, and Prof. Harald Rose from TU Darmstadt. The scientists received the award worth US$ 100,000 in recognition of their work advancing electron microscopy. The prize was presented by the President of the State of Israel, Shimon Peres, and the Minister of Education, Gideon Sa'ar, in the Israeli Parliament or Knesset in Jerusalem. The Wolf Prize has been awarded to outstanding scientists and artists throughout the world since 1978. It is considered to be one of the most important international awards in the run-up to the Nobel Prize.


1


2

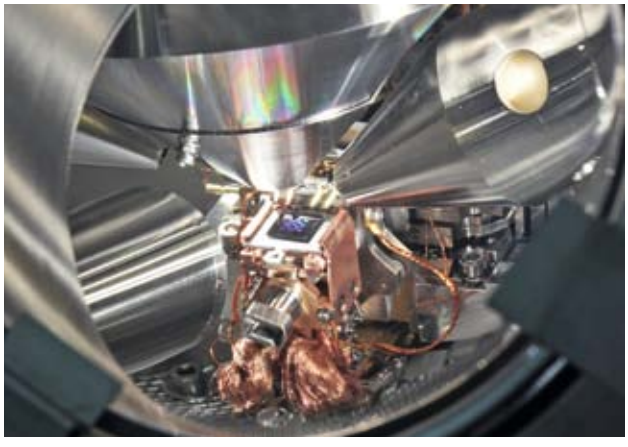

3


4

1 | *Alexander von Humboldt Professor – Prof. Dr. David DiVincenzo*
2 | *Fellow of the American Physical Society – Prof. Dr. Ulf-G. Meißner*
3 | *Recipient of the "Rapid Response Innovation Award" – Prof. Dr. Dr. Peter Tass*
4 | *Winner of the Wolf Prize for Physics – Prof. Dr. Knut Urban*

● Other prizes and awards

Name	Award
Prof. Dr. Katrin Amunts Institute of Neuroscience and Medicine	Editor's Choice Award from the journal Human Brain Mapping
Dr. Sven Cichon Institute of Neuroscience and Medicine	Wilhelm Feuerlein Prize from the German foundation Oberberg Stiftung Matthias Gottschaldt
Anna Dovern Institute of Neuroscience and Medicine	Bursary from the Christiane Nüsslein-Volhard Foundation
Andreas Hospach Institute of Energy and Climate Research	Young Scientist Award for a presentation at the International Thermal Spray Conference & Exposition in Singapore
Dr. Anne Kunz Institute of Energy and Climate Research	Award from the German Metereological Society (DMG)
Justin Lecher Institute of Complex Systems	NRW Young Scientist Award in Structural Biology from the NRW Research School BioStruct
Prof. Dr. Heiner Müller-Krumbhaar Peter Grünberg Institute	Badge of honour from the German Physics Society (DPG)
Dr. Rolf W. Steinbrech Institute of Energy and Climate Research	Seeger medal from the German Ceramic Society (DKG)
Prof. Dr. Hans Ströher Nuclear Physics Institute	Advanced Grant from the European Research Council (ERC)
Dr.-Ing. Günter Subklew Institute of Bio- and Geosciences	Medal of honour from the Association of German Engineers (VDI)
Prof. Dr. Karl Zilles Institute of Neuroscience and Medicine	Honorary doctorate from the University of Rostock, elected member of the North Rhine-Westphalian Academy of Sciences and Humanities



Award-winning photo. In the photo competition "NanoMicro+ Materials from NRW 2010", the jury selected this close-up of the nano spintronics cluster tool taken by Ralf-Uwe Limbach, photographer at Forschungszentrum Jülich, as one of the eleven best entries in the "nano" category.

Prof. Achim Bachem, Chairman of the Board of Directors of Forschungszentrum Jülich, received an honorary guest professorship from the Chinese Academy of Sciences and an honorary professorship from Shanghai Jiao Tong University during his visit to China.

Third-Party Funding

Third-party funding reflects trust. The German federal government and federal states, the German Research Foundation (DFG) and companies invest in Jülich research because they bank on research findings here with sustained benefits for society which also facilitate important innovations in industry. The fact that the volume of third-party funding acquired by Jülich researchers has continuously increased confirms that Jülich has not disappointed these expectations.

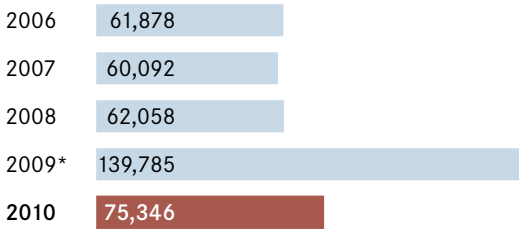
Research funding

- Balance sheet 2010

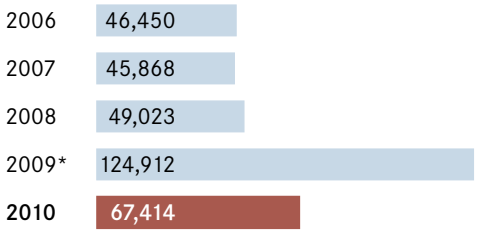
	Thousands of euros
Federal government project funding	50,641
Federal state project funding	6,742
DFG funding	4,166
Other national sources	5,865
Total national	**67,414**
EU	7,932
Total Europe	**7,932**
Sum total	**75,346**

Note:
- Federal government project funding includes € 19,612,000 for the operating costs of ILL Grenoble.
- DFG funding does not include DFG earnings amounting to € 95,000 as they have been generated within the framework of private service contracts and therefore do not count as operating income of Forschungszentrum Jülich.

- Research funding from national and international public sources (thousands of euros)



- Research funding from national public sources (thousands of euros)

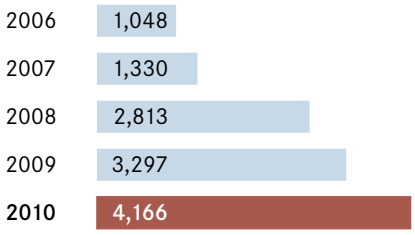


* In 2009, national project funding was significantly higher because it included funds for the installation of a petaflop computer.

- The number of DFG-funded projects in Jülich remained at a high level in 2010 with a total of 39.

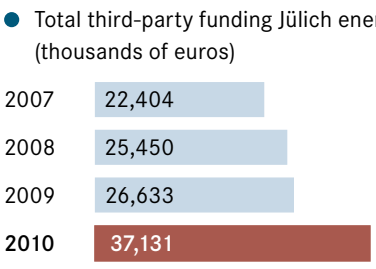
Collaborative Research Centres	12
DFG Priorities	18
Research Training Groups	6
DFG Research Units	3

- DFG funding (thousands of euros)



"The transition to sustainable energy supply is an extremely important topic for the future. In this context, the Federal Government is promoting the increased use of renewable energy and the efficient use of energy in general." — Taken from the federal government's High-Tech Strategy for Germany

Particularly successful in acquiring third-party funding in 2010: Jülich energy research



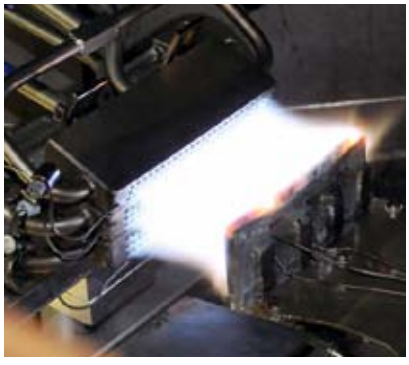
Exemplary projects funded by third parties in energy research

ADELHEID | Fuel cells will sustainably supply cars, aircraft and boats with energy in the future. At Jülich, reformers for these fuel cells have been developed. They generate the fuel required from diesel or kerosene. In order to develop this technology to market maturity, Jülich scientists are conducting joint research with partners from industry as part of the ADELHEID project. The objective is to create production techniques with the potential for commercialization, also taking economic aspects into account. The state of North Rhine-Westphalia (NRW) agreed to fund the project for three years beginning in 2010 with € 2 million. Of this, approximately **€ 530,000** will be used for Jülich research (for more information, see p. 67).

BRINKS | Efficient five-kilowatt fuel cell systems for on-board power supply in aircraft are being developed by Jülich researchers in the BRINKS project. Stacks of high-temperature polymer electrolyte fuel cells (HT-PEFCs) are characterized by flexible cooling and a simple fabrication technique. The modular construction means that they can be adapted to meet different demands. The hydrogen for the HT-PEFC is supplied by a compact fuel processing system with autothermal reforming of kerosene. The Federal Research Ministry (BMBF) is funding the project with **€ 3.47 million**.

NASA-OTM | The objective is to generate energy from coal and to protect the climate in so doing. In the oxyfuel process, a membrane separates oxygen from air with low efficiency losses and this oxygen is then used to burn coal. The end product is highly concentrated carbon dioxide, which will then be stored underground. In the EU project NASA-OTM, thin ceramic membranes with a high oxygen flow are being developed for this purpose. Eight partners from five countries are involved. Dr. Wilhelm Meulenberg from Forschungszentrum Jülich is the coordinator (www.nasa-otm.eu). In the EU's Seventh Framework Programme, Jülich was awarded funding totalling **€ 995,799** for the project (September 2009 – August 2012), of which it received **€ 340,424** in 2010.

HolisTurb | The efficiency and reliability of aircraft engines can be increased by applying ceramic coatings to gas turbine components. In the HolisTurb project, the coating technology developed by Forschungszentrum Jülich together with Rolls-Royce Deutschland Ltd & Co KG is being refined and transferred to industrial partners. In addition, Jülich researchers are constructing test stands for tests under realistic conditions. The Federal Ministry of Economics and Technology (BMWi) has allocated **€ 720,000** for the work in Jülich between 1 October 2009 and 31 March 2012.



The natural gas oxygen burner in the new test stand for gas turbine components in an aircraft engine. Scientists at Forschungszentrum Jülich developed it for aircraft engine manufacturer Rolls-Royce.

The PTJ Berlin office celebrated twenty years of service in 2010. At the function in Berlin, welcome speeches were given by Thomas Rachel (right), Parliamentary State Secretary in the Federal Ministry of Education and Research, and Dr. Ulrich Krafft (middle), Vice-Chairman of the Board of Directors of Forschungszentrum Jülich. Dr. Ulrich Schlüter, head of PTJ, is pictured on the left.

Project Management Jülich

Project Management Jülich (PTJ) is one of the leading project management organizations in Germany. With expertise in research and innovation management, it supports its clients in the German federal and state governments in implementing their research programmes. In addition, it functions as a National Contact Point for European Commission research funding.

PTJ coordinates research and innovation funding programmes in the areas of biotechnology, energy, materials technologies, environment and sustainability, marine and polar research, navigation and marine technology, technology transfer and start-up companies, as well as regional technology platforms and clusters.

With around 2,200 projects and a funding volume of € 380 million, the field of energy is the largest area, followed by biotechnology with 2,000 supported projects and a funding volume of € 242 million.

2010

- Project Management Jülich

invested around € 1.1 billion of funding;
approved around 3,000 new projects;
supported a total of over 9,000 projects.
The number of employees rose to 540.

Super Research Thanks to Supercomputers

Computer simulations with high-performance computers is a key technology, upon which many new findings from almost every scientific discipline, new processes and ultimately new products are based. The use of supercomputers is therefore also the element that links two outstanding results achieved by Jülich scientists in 2010. One team deciphered the processes that take place when data is stored on DVD materials. Another team uncovered the principles of the binding behaviour of small protein molecules on silicon surfaces – a combination that is interesting for electronic components and sensors of the future.

Really, it's quite incredible. Although rewritable DVDs have been on the market for more than ten years and have long since become a mass product with sales figures in the billions, up to now, it was unclear exactly what happens when data is written. This changed only recently. In 2010, researchers from Jülich, Finland and Japan uncovered the physical principles of data storage on DVD-RWs, having successfully done the same for DVD-RAM and Blu-Ray Discs the year before. In addition to experiments at the Spring-8 synchrotron in Japan, they made use of intensive simulations on the Jülich supercomputer JUGENE. Their findings, however, are not just simply meant to satisfy scientific curiosity; they could also aid the development of even more efficient storage materials.

In contrast to DVD-Rs, which can only be written to once as data is burned onto a thin layer of an organic dye, the information-carrying layer in a rewritable DVD is made of an alloy. Digital information is saved in bits in defined areas around a hundred nanometres in size. The alloy can take on an unordered (amorphous) and an ordered (crystalline) structure corresponding to the basic elements of all computer languages – zero and one. The transition between the two phases takes only a few billionths of a second and is triggered during writing by the laser pulse of the DVD burner.

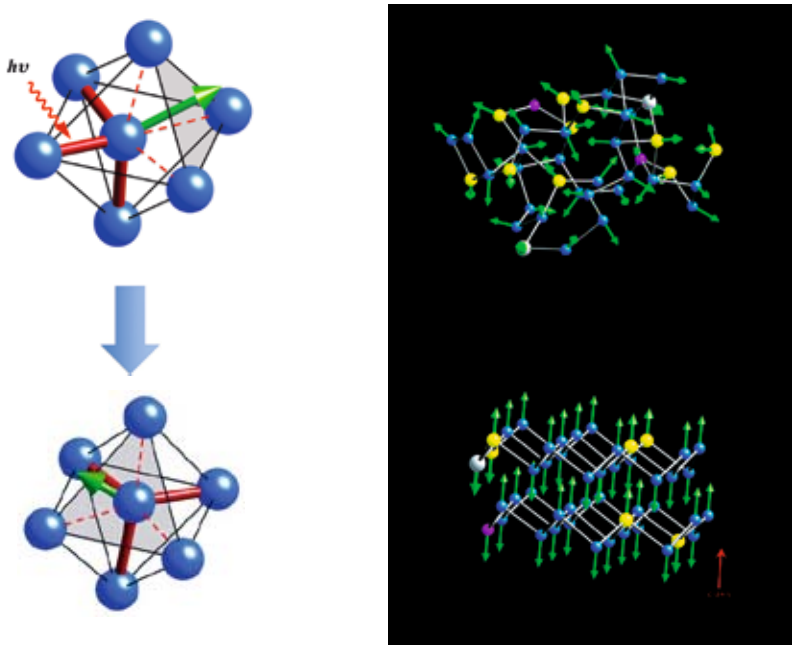
The Jülich supercomputer JUGENE helped a team of international researchers to get to the bottom of the physical principles of data storage on DVDs and Blu-Ray Discs.

How a bit grows

In the case of DVD-RWs, the alloy consists of antimony, indium, silver and tellurium. Specialists refer to it as AIST for short. Alloys used in DVD-RAMs and Blu-Ray Discs are known as GST alloys. They too contain antimony and tellurium with the addition of germanium. "Although the alloy families AIST and GST appear to be very similar, their phase transitions are very different," says Jülich scientist Dr. Robert Jones, explaining the research findings. In the AIST alloy, the phase transition of a bit proceeds from the outside to the inside. In other words, during the rewriting of a DVD an amorphous bit is transformed into a crystalline bit, causing it to crystallize progressively, starting from the edge with which it adjoins the ordered surroundings. The decisive factor here is the reorganization of the amorphous bit caused by a small movement of the antimony atom. A sequence of many small steps results in the reorientation and crystallization of the lattice atom by atom without the need for cavities or large movements. In essence, the antimony atoms excited by the laser pulse only change the bond strength between two neighbouring atoms. The researchers therefore refer to their description of the processes as the "bond-interchange model".

In contrast to this, crystals are formed spontaneously inside GST alloys in DVD-RAMs or Blu-Ray Discs and they grow quickly until the bit is full. The fast transition can be explained in that amorphous and crystalline phases consist of the same four square units, which move and rearrange themselves in the available cavities without causing many atomic bonds to break.

The structural calculation of amorphous AIST was the largest ever performed in this area of research. Around 640 atoms were simulated over the comparatively long time of several hundred picoseconds. Around 4,000 processors of the JUGENE supercomputer were fully utilized for more than four months in order to determine the correct model conditions.



Model of the crystallization of the AIST alloy in a DVD-RW. Left: A laser pulse (left, arrow hv) causes the central antimony atom to move, which then replaces short bonds (thick red lines) to two neighbours with long bonds (dotted red lines). This then leads to a change in the green vector sum of the three short bonds.
Right: A sequence of such processes leads from the amorphous (top) to the crystalline form (bottom).

Realizing visions of the future

While Jones and his colleagues were taking a closer look at the DVD as an existing product for data processing, the research of another team of scientists looked far into the future of information technology. Combinations of organic molecules and semiconductor or metal surfaces are considered promising candidates for novel electronic components. Visions of the future include highly sensitive sensors capable of detecting a single molecule and the merging of electronics with human brain functions – for example, in the form of implants allowing blind people to see again or people who cannot walk to control their prostheses with their thoughts. "But before such applications are possible, systematic fundamental investigations and an understanding of the cooperative interactions of inorganic and organic matter are required," says Jülich physicist Dr. Michael Bachmann. Together with researchers at the universities of Leipzig and Lund, he simulated the binding behaviour of peptides on silicon surfaces using computers such as the Jülich supercomputer JUROPA. Silicon is technologically one of the most important semiconductors and it is used as a substrate in microelectronics, while peptides in the body are important as hormones or neurotransmitters in the nervous system. The results showed that the folding and adhesion behaviour of simulated peptides depended primarily on the exact position of individual amino acids. When the researchers fabricated the designer peptides in reality, their findings were verified. It could therefore be possible in future to predictably control the adhesion behaviour and folding properties of peptides by altering selected amino acids – the specialists refer to this as selective mutation.

Excellent Platforms

The supercomputers in the Jülich Supercomputing Centre (JSC)

In the Jülich Supercomputing Centre, scientific users work closely with JSC employees. This leads to a fruitful deployment of the European supercomputing centre at Jülich – particularly for the development of methods and for scientific visualization.

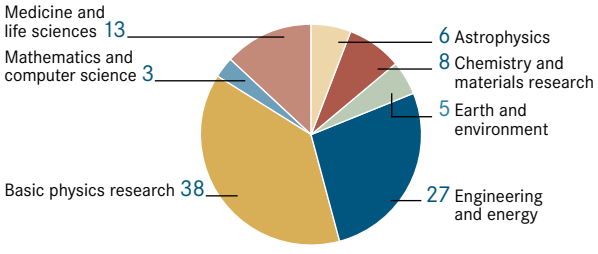
- User statistics

In 2010, **2 billion** processor hours were allocated on JUGENE and almost **125 million** on JUROPA (whereby the JUROPA processors are more powerful than the JUGENE processors).

- Coveted computing time – Overbooking factor

JUGENE **4** JUROPA **7**

- JUGENE research fields in ongoing European projects (PRACE) 2010

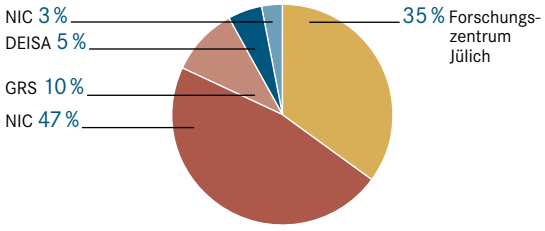


In 2010, within the framework of the Partnership for Advanced Computing in Europe (PRACE), nineteen European projects were calculated on JUGENE. Most of the computing time – 38% – was assigned to basic physics research, followed by the research area of engineering and energy with 27%.

Relative numbers according to users

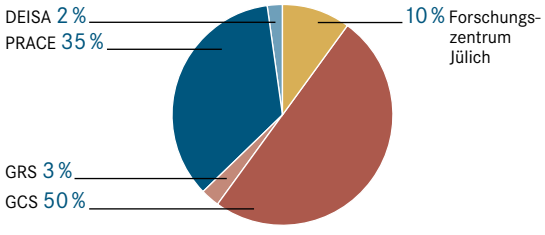
- Juropa

Europe (DEISA and NIC) 8 %
Germany (NIC and GRS) 57 %



- Jugene

Europe (PRACE and DEISA) 37 %
Germany (GRS and GCS) 53 %



The Jülich supercomputers were used extensively by users outside Forschungszentrum Jülich. The computing time was allocated by Forschungszentrum Jülich.
GCS: Gauss Centre for Supercomputing (association of the three national supercomputing centres JSC, HLRS and LRZ)
NIC: John von Neumann Institute for Computing (national allocation body, funded by the three Helmholtz Centres FZJ, DESY, GSI)
GRS: German Research School for Simulation Sciences
PRACE: Partnership for Advanced Computing in Europe (European HPC infrastructure)
DEISA: Distributed European Infrastructure for Supercomputing Applications (European HPC infrastructure, forerunner of PRACE)

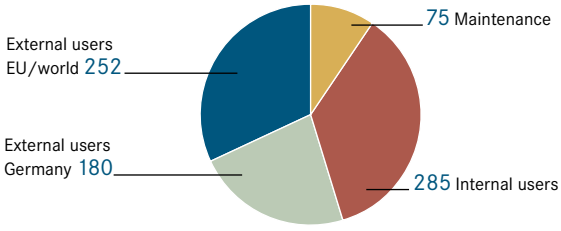
View from the sample position of the small-angle scattering facility KWS 2 back to the reactor wall. The distances over which the neutron beam is concentrated can be seen: on the right, KWS 2, and on the left, KWS 1. Further back, the neutron speed selectors in the lead shielding can be seen. On the reactor wall, the supply of neutrons to all instruments is shown.

View into the focusing section of KWS 2 during refurbishment at the end of 2010. The vacuum housing containing the neutron guide system can be seen. In the rightmost position is a neutron guide one metre long, which can be inserted and withdrawn via the pressure cylinder on the right. The slide system also drives the magnetic guide for the polarized neutrons.

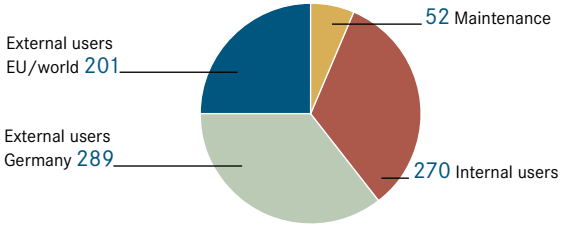
The instruments at the Jülich Centre for Neutron Science (JCNS)

JCNS operates neutron research instruments at leading international neutron sources. For this reason, JCNS is also responsible for the construction and operation of the Jülich instruments at the Heinz Maier-Leibnitz research neutron source (FRM II) in Munich. These instruments are available to external scientists. In addition, JCNS operates instruments at the Institute Laue-Langevin in Grenoble, France, and at the Spallation Neutron Source in Oak Ridge, USA.

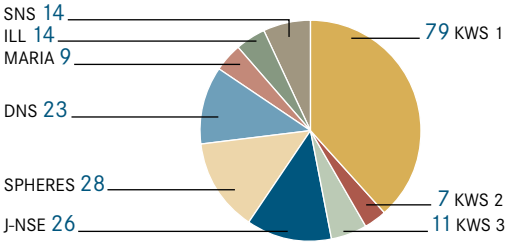
- Beam time allocated by JCNS (days) at FRM II 2009 (KWS 2, J-NSE, DNS, SPHERES)*



- Beam time allocated by JCNS (days) at FRM II 2010 (KWS 1, KWS 2, KWS 3, J-NSE, DNS, SPHERES)*



- Use of JCNS neutron scattering instruments by external researchers, days 2010



* KWS 1 Small-angle scattering facility 1
KWS 2 Small-angle scattering facility 2
KWS 3 Small-angle scattering facility 3
J-NSE Jülich neutron spin echo spectrometer
SPHERES Backscattering spectrometer with high energy resolution
DNS Time-of-flight spectrometer with diffuse neutron scattering
MARIA Reflectometer for thin magnetic layers
ILL Institut Laue-Langevin, Grenoble
SNS Spallation Neutron Source, Oak Ridge

Coveted instruments: Scientists outside of Forschungszentrum Jülich applied for a total of 1,192 working days at the Jülich instruments for neutron research. On 211 days, experiments were actually conducted by external users. Measurement time is allocated to external users by an international selection committee.

Ernst Ruska Centre (ER-C)

With the Ernst Ruska Centre (ER-C), Forschungszentrum Jülich and RWTH Aachen University operate a centre of excellence for atomic-resolution electron microscopy and spectroscopy on the highest international level. At the same time, it is the first national user centre for high-resolution electron microscopy. ER-C provides scientists with access to what are currently the most powerful electron microscopes, including high-performance "Titan 80-300" electron microscopes. Half of the usage time is made available to universities, research institutions and industry. This time is allocated by a panel of experts nominated by the German Research Foundation (DFG).

● Usage of the Titan instruments

	2006	2007	2008	2009	2010*
ER-C (days)	38	85	103	134	145
RWTH (days)	264	65	70	80	63
Forschungszentrum Jülich (days)	68	151	143	110	89

* Data for 2010: as of 30 November 2010 incl. bookings for December 2010

Cooler Synchrotron (COSY)

COSY is like a microscope for the components of a nucleus – the protons and neutrons. Since the particle accelerator went into operation in 1993, its user community has grown steadily. Applications are therefore made for more beam time than Forschungszentrum Jülich can actually provide. A Program Advisory Committee made up of internationally recognized physicists from the USA and Europe decides which applications to accept. Applications are submitted by interested scientists from universities abroad and in Germany as well as by Jülich researchers. Ultimately, outstanding ideas decide who is allowed to perform experiments with COSY.

● COSY users

Year	Users
2005	350
2006	380
2007	411
2008	432
2009	452
2010	502

Personnel

Certification and inspiration: Audit “berufundfamilie”

With a committed personnel policy, Forschungszentrum Jülich supports its employees in reconciling family and career. In August 2010, berufundfamilie gGmbH – an initiative supporting and encouraging the reconciliation of work and family life – awarded the “berufundfamilie” certificate to Jülich.

The certification process is twofold. On the one hand, it certifies that Forschungszentrum Jülich is a family-friendly employer as it stands today. This had also been confirmed previously by the Total E-Quality Award, which Jülich received for the fourth time in 2009. However, the audit is also an incentive for Jülich to continue promoting its family-friendly and equal opportunities policies. The Equal Opportunities Bureau is responsible for this ongoing project.

Forschungszentrum Jülich will now be re-audited over a three-year period. During the auditing period, defined objectives must be achieved.
For example,

- more consideration of problems associated with combining work and family life in personnel talks between employees and their superiors;
- additional courses in an effort to promote health, e.g. dealing with stress or conflict management;
- introduction of further training and education measures via e-learning, which are independent of time and place and which are easier to reconcile with family obligations;
- a survey and analysis of stress situations at home which have an influence on professional obligations, conducted as part of an undergraduate thesis in psychology;
- creation of a dual career service in a network with partner organizations in the Cologne, Bonn and Aachen area, offering partners of new employees at Jülich support in finding appropriate employment in the region.

Forschungszentrum Jülich sees the “berufundfamilie” audit as an opportunity to review its existing structures and range of services aiming to reconcile work and family life, to develop new measures, and thus to implement its guiding principles.

Forschungszentrum Jülich supports the “Kleine Füchse” day-care centre, which offers childcare for sixty children between the ages of six months and fourteen years.

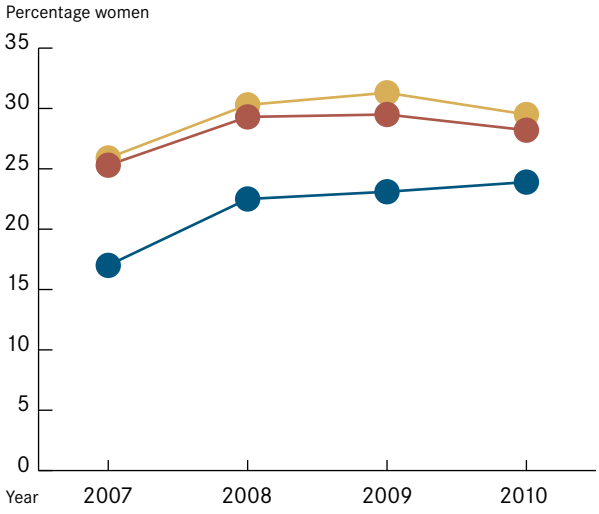
During girls' day, thirty-six secondary school girls learnt that even those areas of science dominated by men up to now can be interesting for women. Women scientists from the Institute of Neuroscience and Medicine, the Institute of Bio- and Nanosystems and the Institute of Energy and Climate Research provided the girls with insights into their work.

● Overview personnel as of 31.12.2010

Area	Number up to 31.12.2010
Scientific and technical personnel	3,268
Scientific personnel	**1,625**
• incl. PhD students/scholarship holders*	443
• incl. undergraduates	112
• incl. professors** W3: 40, W2: 27, W1: 2	69
Technical staff	**1,643**
Project management organizations	575
Service staff and administration	624
Trainees and students on placement	300
Total	4,767

* 672 PhD students were supervised in total at Forschungszentrum Jülich in 2010 (cumulative, not correct as of 31.12.2010). An additional 49 PhD students from the Heinrich Heine University Düsseldorf were also working at the university institutes located on campus at Jülich. This therefore gave a total of 721 PhD students at Jülich in 2010.
** only those professors appointed according to the Jülich model, i.e. adjunct professors or other professors are not included.

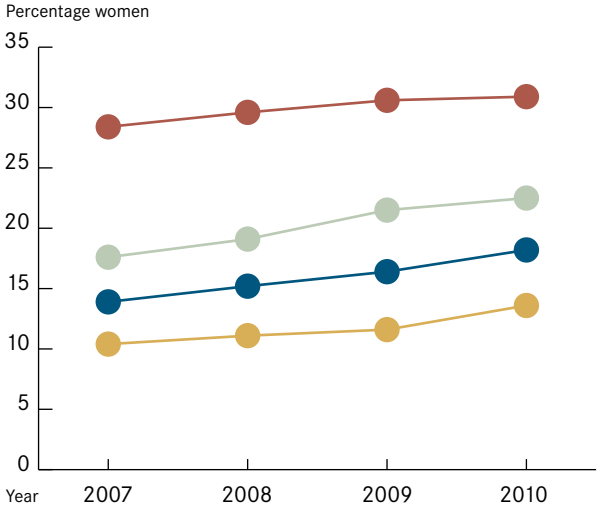
● Proportion of young women



- Total percentage young women
- Percentage women trainees
- Percentage young women scientists

The figures are based on equivalent full-time employees (FTEs); the real number of employees is higher as a result of part-time employment.

● Proportion of women employees at Forschungszentrum Jülich



- Women as a percentage of total employees
- Women as a percentage of senior personnel – total
- Women as a percentage of scientific personnel
- Women as a percentage of salary groups E12 to E15Ü, as well as those paid according to groups AT, B, C and W (specialist staff)

The figures are based on equivalent full-time employees (FTEs); the real number of employees is higher as a result of part-time employment.

Appointments of Jülich Researchers to Universities

Privatdozent Dr. Michael Bachmann, Institute for Advanced Simulation, accepted an offer to move to the University of Georgia in Athens (USA) as an associate professor of physics.
Dr. Reinhard Walter Carius, Institute of Energy and Climate Research, was appointed professor of photovoltaics at Aachen University of Applied Sciences.
Prof. Evgeny Epelbaum, Nuclear Physics Institute, was offered an appointment as professor (salary grade W3) of theoretical physics at Ruhr University Bochum.
Dr. Philipp Eschenbeck, Institute of Neuroscience and Medicine, was appointed professor of ergotherapy at the University of Health Sciences Bochum.
Jürgen-Friedrich Hake, Institute of Energy and Climate Research was appointed professor at the Faculty of Energy Technology, Aachen University of Applied Sciences.
Dr. Elke Kalbe, Institute of Neuroscience and Medicine, was appointed adjunct professor at the University of Bielefeld.
Dr. Wilhelm Meulenberg, Institute of Energy and Climate Research, was appointed adjunct associate professor at the University of Queensland in Australia.
Dr. Christoph Palm, Institute of Neuroscience and Medicine, was appointed professor at the University of Regensburg for the area of signal and image processing in medicine.
Dr. Willem Quadakkers, Institute of Energy and Climate Research was appointed professor at the Faculty of Energy Technology, Aachen University of Applied Sciences.
Prof. Claus M. Schneider, Peter Grünberg Institute, was the first professor to be appointed by the University Alliance Metropolis Ruhr (UAMR). In addition to his work at Forschungszentrum Jülich, Prof. Schneider now researches and teaches at the universities of Bochum, Duisburg-Essen and TU Dortmund.
Dr. Armin Seyfried, Institute for Advanced Simulation, was appointed professor of computer simulation for fire protection and evacuation at the University of Wuppertal.
Prof. N. Jon Shah, Institute of Neuroscience and Medicine, was appointed professor of magnetic resonance physics at Maastricht University.
Dr. Achim Streit, Jülich Supercomputing Centre, was offered an appointment as professor of distributed and parallel high-performance systems and a position as director at the Steinbuch Centre for Computing (SCC) at Karlsruhe Institute of Technology (KIT).
Dr. Bernhard Unterberg, Institute of Energy and Climate Research, was appointed professor of fusion research at Ruhr University Bochum in accordance with the Jülich model.
PD Dr. Achim Walter, Institute of Bio- and Geosciences, accepted an appointment as professor of agronomy and plant breeding with the Institute of Plant Science at the Swiss Federal Institute of Technology (ETH) in Zurich.
Prof. Dr. Peter Weiss-Blankenhorn, Institute of Neuroscience and Medicine, was appointed professor (salary grade W2) of cognitive neurology at the University of Cologne.
Prof. Dr. Felix Wolf, Institute for Advanced Simulation, was appointed full professor of informatics at RWTH Aachen University, where he will undertake teaching and research work for the German Research School for Simulation Sciences at the Aachen site.

An information event for PhD students enrolled at the German Research School for Simulation Sciences (GRS) – a joint institution set up by RWTH Aachen University and Forschungszentrum Jülich – with Managing Director Vera Kleber (left).

Prof. N. Jon Shah Teaches at Maastricht

Prof. N. Jon Shah, director at the Institute of Neuroscience and Medicine, Forschungszentrum Jülich, was appointed honorary professor at Maastricht University. President of Maastricht University Prof. Jo Ritzen presented Shah with his letter of appointment after the signing of a cooperation agreement in the area of imaging techniques between the university and Forschungszentrum Jülich. The aim behind the cooperation is to create a European centre of excellence in the field of ultrahigh-field magnetic resonance imaging.

Lecturers at Aachen University of Applied Sciences and the Jülich Supercomputer Centre are involved in teaching trainees intending to qualify as mathematical and technical software developers. Prof. Paul Jansen is pictured here.

Joint appointments with universities (status at Jülich)

- appointments as of 31.12.2010*

University	Jülich model	Reverse model	Total
FH Aachen	7	0	7
HHU Düsseldorf	10	2	12
RWTH Aachen	23	4	27
Uni Bochum	3	0	3
Uni Bonn	6	2	8
Uni Duisburg-Essen	1	0	1
Uni Cologne	6	1	7
Uni Münster	1	0	1
Uni Wuppertal	3	0	3
Total	60	9	69

*only professors appointed according to the Jülich model
Jülich model: Directors of institutes at Forschungszentrum Jülich are appointed professor in a joint procedure with one of the neighbouring universities and are simultaneously seconded by the university to Forschungszentrum Jülich in order to fulfil the duties associated with being head of institute at Jülich.

- New appointments 2010

University	Jülich model
FH Aachen	3
Uni Bochum	1
Uni Bonn	1
Uni Cologne	1
Uni Wuppertal	1
Total	7

Includes only those professors appointed according to the Jülich model, i.e. adjunct professors or other professors are not included.

Training with Prospects

For fifty years, young people have been able to avail of first-class vocational training at Jülich. On 1 April 1961, the first seventeen trainees were accepted in five different occupations. Today, Forschungszentrum Jülich offers around eighty-five places for trainees in up to twenty-five occupations. Of these twenty-five occupations, five offer the option of combining vocational training with university studies.

In 2010, more than half of all the trainees at Jülich completed their final examination with the grades of "good" or "very good". With this, the five-year average for examination results has continued to increase over the past few years. Four trainees – two mathematical and technical software developers (MATSEs), one biology laboratory assistant and one physics laboratory assistant – qualified as the best in the federal state. Of these, the very best trainee was Carsten Karbach, who completed his MATSE examination with 100 %, making him the best in Germany. At the fifth official event in honour of the best trainees nationwide held in Berlin, Federal Minister for Labour and Social Affairs, Dr. Ursula von der Leyen, congratulated Karbach on his performance.

Dual study

Vocational training plus university studies – this is what dual study is. Trainees with this dual qualification are much sought-after because of their ability to work at the interface between scientific issues and technical implementation. Closely linking vocational training with university studies aims to counteract the expected shortage of highly qualified personnel. Of 298 trainees, a good quarter availed of the opportunity to simultaneously undertake university studies in 2010. For new trainees, this figure rose to almost one third.

Forschungszentrum Jülich has been active in developing new dual study courses in the areas of mechanical engineering, electrical engineering and physics. Aachen University of Applied Sciences, the vocational colleges in Jülich and Düren, and the Aachen Chamber of Industry and Commerce (IHK Aachen) were also involved.

Vocational training at Jülich also contributes to regional development in the form of collaborations with small and medium enterprises, supporting vocational training in these companies. This includes basic training, specialized courses and examination preparation for trainees in twenty-one partner companies.

Forschungszentrum Jülich trains more skilled personnel than it actually needs. Chemistry laboratory assistants have trained at Jülich since 1962.

1 April 1961
Kick-off – seventeen trainees start their training as mechanics, radio and television technicians, power engineering technicians, electricians and physics laboratory assistants. Ludwig Pley is the first full-time instructor at Jülich.

1 April 1964
Dieter Litterscheidt becomes head of apprentice training (until 30 April 2003). A mechanical teaching work shop is set up on the site of the former federal railways repair shop (BAW).

1 January 1965
Physics training laboratory built.

1 April 1967
Chemistry training laboratory built.

1 January 1970
Training in electrical and electronic trades set up.

1970
Ten full-time instructors working at Jülich.

50 Years of Vocational Training
CAREERS MADE IN JÜLICH

Clears all hurdles: Carsten Karbach completed his MATSE examination as the best in the country and is now pursuing a master's in technomathematics.

● Places for trainees – new positions 2010

Laboratory assistants	23	incl. chemistry studies	2
Electricians	13	incl. dual study	2
Metalworkers	12	incl. dual study	2
Technical draftsmen	2		–
Office staff	11	incl. dual study	2
Math. and tech. assistants	21	incl. study	21
Other	4		–
Total	86	incl. study	29 (34 %)

● Dual study – an overview

	Duration	IHK examination	Bachelor's degree
Bachelor of Scientific Programming + mathematical and technical software developer (MATSE), IHK	3 years	after 3 years	after 6 semesters
Bachelor of Science or Bachelor of Engineering + chemistry laboratory assistant, IHK	4 years	after 3 years	after 8 semesters
Bachelor of Mechanical Engineering + industrial mechanic, IHK	4 years	after 2.5 years	after 8 semesters
Bachelor of Electrical Engineering + electronics engineer for technical services, IHK	4 years	after 2.5 years	after 8 semesters
Bachelor of Arts in Business Administration + office communications specialist, IHK	3.5 years	after 3 years	after 7 semesters

1988
MONALISA training concept developed and first marketed externally in 1991. In 1997, it was awarded the initiative prize for education and training by the Otto Wolff von Amerongen Foundation.

1998
Dual study – start of a new concept combining vocational training and courses at a university of applied sciences.

16 February 2011
"Barkeeper" – first place for an automated cocktail mixer and the Inspiring Award in the Nanoline Contest in cooperation with the vocational college for technology in Düren.

23 March 2011
"Gouden Spatel 2010" – Having completed a dual study programme, Stefanie Klein is nominated for the award on the basis of her bachelor's dissertation.

Early-Career Scientists

The Best Conditions for a PhD – Graduate Schools and Research Training Groups

Writing a PhD is the first independent scientific work that a young researcher will complete. However, working independently does not have to mean getting to grips with the PhD project all on your own. Graduate schools and research training groups support early-career scientists in their work with structured programmes comprising courses, workshops and seminars. The requirements laid down by the German Research Foundation (DFG) for funding such groups are high: a thematically focused research programme, originality and high scientific quality at an international level, as well as a strong training concept. Forschungszentrum Jülich is involved in nine DFG-funded research training groups at different partner universities. One example is the International Research Training Group "Schizophrenia and Autism", in which the Jülich Aachen Research Alliance JARA-BRAIN has been actively involved since 2006. The partner university here is the University of Pennsylvania. After a successful evaluation, further funding in excess of € 4 million was granted in July 2010 for another four and a half years. Getting funding for graduate schools within the framework of the Excellence Initiative is even more difficult. The idea behind these schools is to provide PhD students with ideal conditions and to increase the recognition and prestige of excellent, internationally competitive centres in Germany. In the first funding phase, thirty-nine graduate schools throughout Germany were approved, two of which involved Jülich: the Aachen Institute for Advanced Study in Computational Engineering Science (AICES) and the Bonn-Cologne Graduate School.

The Jülich Excellence Prize

The building blocks for medications can be created using enzymes. While working on her PhD, biologist Dr. Dörte Rother developed a sort of construction kit for pharmacists. Early-career physicist Dr. Sebastian Feste focused on current issues associated with nanoelectronics. He investigated how mechanically strained silicon can be used to increase the performance of certain computer components. Both scientists were awarded the Excellence Prize in 2010 and each received € 5,000. Forschungszentrum Jülich awards the Excellence Prize to its most able early-career scientists who also count among the best in their year according to international standards. Prizes were awarded in June 2010 at the annual function for Jülich PhD students, "JuDocs – Careers Made in Jülich".

Dörte Rother emphasizes the importance of interdisciplinary cooperation. "I don't have to do everything myself, but I do have to understand what the chemist or engineer means."

For Sebastian Feste, the usefulness of his research is important. "The link between industry and science is what attracted me when I decided to accept a position as a PhD student at Jülich."

● Involvement of Forschungszentrum Jülich in structured PhD training with partner universities

Lead institutions	Graduate schools, research training groups	Cooperation, funding	Further information
Aachen	Aachen Institute for Advanced Study in Computational Engineering Science (AICES), graduate school within the Excellence Initiative	Aachen, DFG	www.aices.rwth-aachen.de
	International Research Training Group: Brain-behaviour relationship of emotion and social cognition in schizophrenia and autism	Aachen, Jülich, Philadelphia, DFG	www.irtg1328.rwth-aachen.de
	Research Training Group: Biointerface – detection and control of interface-induced biomolecular and cellular functions	Aachen, DFG	www.grk-biointerface.de
	Research Training Group: Biocatalysts using non-conventional media – ionic liquids, organic solvents, supercritical fluids and gases as reaction phases for biocatalytic syntheses (BioNoCo)	Aachen, Düsseldorf, DFG	www.bionoco.rwth-aachen.de
Bonn	Bonn-Cologne Graduate School of Physics and Astronomy, graduate school within the Excellence Initiative	Bonn, Cologne, DFG	www.gradschool.physics.uni-bonn.de
	Research Training Group: Bionics – Interactions across Boundaries to the Environment	Bonn, DFG	www.bionikgraduate.uni-bonn.de
Düsseldorf	BioStruct NRW Research School	Düsseldorf, NRW	www.biostruct.de
	Research Training Group: Physics of Hot Plasmas	Düsseldorf, DFG	www.laserphy.uni-duesseldorf.de/e618/index_ger.html
	International Research Training Group: The Dynamic Response of Plants to A Changing Environment	Düsseldorf, East Lansing, DFG	www.igrad-pre.uni-duesseldorf.de
	Research Training Group: Molecular Targets of Aging Processes and Strategies for the Prevention of Aging	Düsseldorf DFG	www.grk1033.uni-duesseldorf.de
Forschungszentrum Jülich	International Helmholtz Research School: BioSoft	Cologne, Bonn/Caesar, Düsseldorf	www.ihrs-biosoft.de
	German Research School for Simulation Sciences (GRS): joint training of master's and PhD students; joint venture between RWTH Aachen University and Forschungszentrum Jülich	Aachen, Helmholtz Association, federal state of NRW, BMBF	www.grs-sim.de
	Helmholtz Interdisciplinary Doctoral Training in Energy and Climate (HITEC)	Aachen, Bochum, Düsseldorf, Cologne, Wuppertal, Helmholtz Association	www.fz-juelich.de/hitec

Forschungszentrum Jülich is actively involved in training PhD students in graduate schools and research training groups. AICES and the Bonn-Cologne Graduate School are graduate schools funded by the Excellence Initiative. Together with five partner universities, Forschungszentrum Jülich received funding from the Helmholtz Association to set up Helmholtz Interdisciplinary Doctoral Training in Energy and Climate (HITEC). Further measures supporting early-career scientists include the spring and summer schools at Jülich, such as the 41st IFF Spring School "Electronic Oxides: Correlation Phenomena, Exotic Phases, and Novel Functionalities" and the WE-Heraeus Summer School "Fast Methods for Long-Range Interactions in Complex Systems". Forschungszentrum Jülich is also involved in the Marie-Curie programmes NOVOBRAIN and VaTEP (Vacuolar transport equipment for growth regulation in plants), which have been granted funding for early-career scientists as part of the EU's Seventh Framework Programme.

Young People Take the Lead

Helmholtz Young Investigators Groups offer young researchers ideal opportunities shortly after they have completed a PhD. They can set up their own research group, take on a position of responsibility and pursue a research project in an independent manner. In 2010, three early-career scientists based at Forschungszentrum Jülich made it through a multistage selection procedure involving external expert assessments and presentations in front of an interdisciplinary panel of judges. Dr. Julia Frunzke, who also won the Excellence Prize of Forschungszentrum Jülich the year before, Dr. Samir Lounis and Dr. Gil Gregor Westmeyer were selected by the Helmholtz Association to head their own young investigators groups.

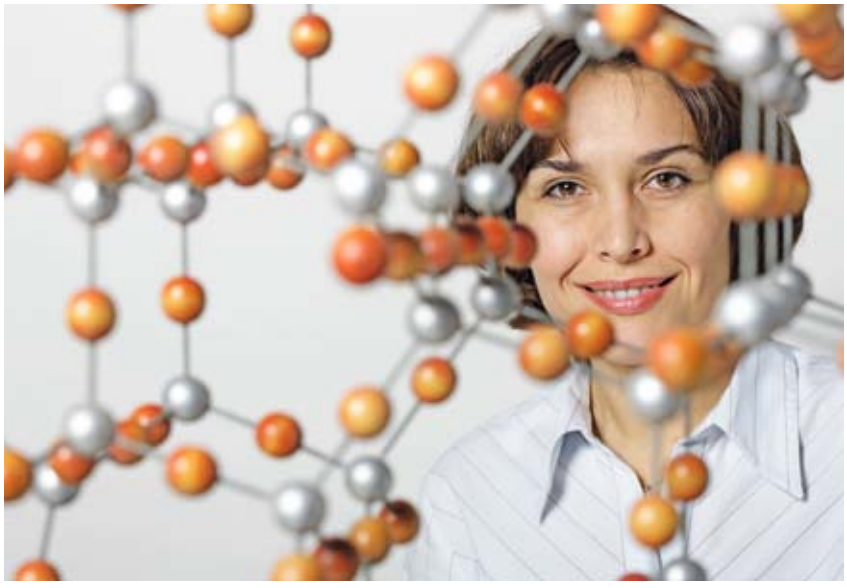
With an annual budget of at least € 250,000, each of them can work on their own research projects for the next five years. If the interim evaluation is positive, they will also be offered permanent positions. At the moment, there are twenty-three young investigators groups at Jülich. Ten of these are headed by women.

In 2010, Dr. Yuri Divin from the Peter Grünberg Institute at Forschungszentrum Jülich joined one of six new German-Russian young investigators groups, which are funded by the programme entitled Helmholtz-Russia Joint Research Groups. The aim is to consolidate cooperation between Russian scientists and the Helmholtz Centres. Divin works together with Dr. Matvey Valerèvich Lyatti from the Kotelnikov Institute of Radio Engineering and Electronics at the Russian Academy of Sciences on the project “Liquid Identification by Hilbert Spectroscopy for Security Screening”. Together, they are developing techniques for the fast and reliable identification of hazardous liquids – for example, for security checks at airports.

TANDEMplus for Women Scientists

“Make yourself heard!” was the advice that Prof. Dr. Ernst Schmachtenberg, Rector of RWTH Aachen University, gave to participants at the official launch of the TANDEMplus mentoring programme for women scientists in November 2010. TANDEMplus is a collaboration project between Forschungszentrum Jülich, RWTH Aachen University and the Karlsruhe Institute of Technology (KIT) aiming to foster career opportunities for young women scientists. It helps women PhD students and postdocs in the natural and engineering sciences to unlock their potential and to set themselves career objectives. As individual mentors, those in executive positions in science or industry support young women scientists in developing strategies to implement these objectives.

Further information:
www.tandemplus.de



The TANDENplus mentoring programming is aimed at young women scientists with a PhD in the natural or engineering sciences or early-career women scientists in the final stages of their PhD who have the potential and motivation to take on an executive position.

Young Talented Single Parent Seeks and Finds

Anna Dovern was looking for childcare for her son during the school holidays when she stumbled across the website of the Equal Opportunities Bureau at Jülich. The young neuropsychologist found information on a bursary offered by the Christiane Nüsslein-Volhard Foundation. She applied – and won twice over.

Research may not be child's play but Anna Dovern still manages to successfully strike a balance between raising a child and pursuing a career.

I thought it was made for me," says Anna Dovern, thinking back to her first reaction when she saw the advertisement by the Nüsslein-Volhard Foundation, which supports excellent young women scientists with children. The mother of a now eight-year-old son is pursuing a PhD under Prof. Gereon R. Fink at the Institute of Neuroscience and Medicine (INM) at Forschungszentrum Jülich. Having quickly made the decision, she applied for funding and was selected as one of the lucky winners in October 2010. She received a bursary for a year to help her balance her private and professional life. At the same time, her application for the UNESCO-L'Oréal Fellowship was also selected as one of the top three. The prize money of € 20,000 was divided evenly between the winner – to cover costs from the child minder to travel expenses for conferences – and Forschungszentrum Jülich to promote childcare for employees. The first thing Anna Dovern bought with the money was a dishwasher. "I gain so much time as a result every day," she says. Time that she can use, for example, to play chess with her mathematically gifted son Julian.

Anna Dovern was pregnant before completing her school leaving certificate and her son was born shortly after she had taken her oral examinations. She went on to study as a mother of a young child. Shortly before Julian turned five, his parents separated. All in all, not the ideal prerequisites for a scientific career. With support from her parents and from Julian's father, the determined young woman still managed to succeed. She studied psychology in Maastricht, the Netherlands. "The course there was research-oriented and demanding but also involved less compulsory attendance than in Germany," says Dovern. This was hugely advantageous for the reconciliation of study and family life.

In 2007, she came to Jülich and began work on her master's dissertation. After this, she embarked on a PhD. With her research, Anna Dovern wants to improve our understanding of what happens in the brain of a patient who has suffered a stroke and is no longer able to perform movements that were almost second nature before, such as unlocking a door. "The fact that patients can no longer perform these movements correctly cannot solely be explained by paralysis, which is also a common result of stroke. It has more to do with a cognitive deficit known as apraxia," says Dovern. She wants to find out what causes this and to use this knowledge to create the basis for new treatments.

According to her supervisor, Prof. Peter Weiss-Blankenhorn, "What she has achieved is impressive. We can all learn from her in terms of how she organizes her life." In 2011, Anna Dovern will complete her thesis at INM – and at 28 years of age, she will be much younger than many of her colleagues who have no children.

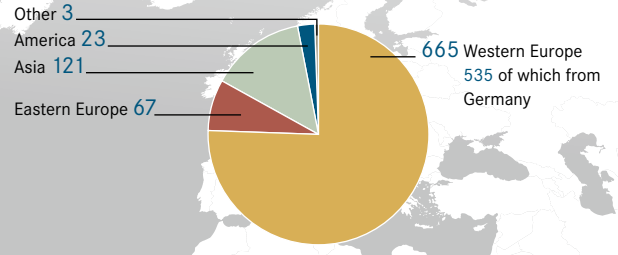
Knowledge Worldwide – Highlights of 2010

In its strategic orientation, Forschungszentrum Jülich attaches great importance to internationalization. It plays a leading role in shaping cross-border research projects and strategic partnerships. The increasing internationalization and networking of Forschungszentrum Jülich with partners throughout the world provides the basis for top internationally acclaimed achievements.

Visiting scientists

● 2010

Total 879
Number of countries 45



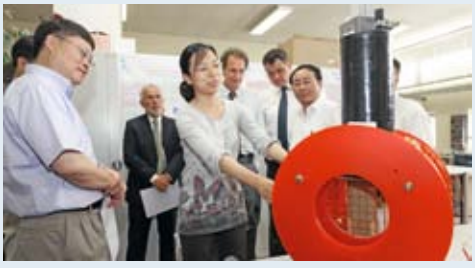
USA

Together with Helmholtz Zentrum Berlin (HZB) and the German Aerospace Centre (DLR), Forschungszentrum Jülich cooperates with the US National Renewable Energy Laboratory (NREL) in the field of renewable energies. The focus is on solar energy projects, including a structured exchange programme for university graduates and PhD students. The Helmholtz-NREL Solar Energy Initiative also opens up opportunities for involving industrial partners in order to ensure that the research findings are effectively implemented in Germany and the USA.

Russia

A joint project between the EU and Russia in the field of high-performance computing was launched in 2010. The project, known as HOPSA (Holistic Performance System Analysis), is coordinated by Forschungszentrum Jülich and has been granted funding totalling € 1.5 million as part of the EU's Seventh Framework Programme. The cooperation aims to develop software and workflows for high-performance computing. In the third call for proposals for Helmholtz-Russia Joint Research Groups, Jülich and the Kotelnikov Institute of Radio Engineering and Electronics at the Russian Academy of Sciences were granted funding worth € 450,000 for the project "Liquid Identification by Hilbert Spectroscopy for Security Screening".

China



The Chinese Academy of Sciences (CAS) has become one of Jülich's strategic partners in China in addition to the elite universities. Chairman of the Board of Directors of Forschungszentrum Jülich, Prof. Achim Bachem, and CAS Vice President, Prof. Jiang Mianheng, signed two agreements on joint research in 2010 – the first in Shanghai during Bachem's visit to China in May, and the second when Jiang came to Jülich in June. The partners want to intensify their cooperation in the fields of bio- and nanoelectronics, materials research, physics and supercomputing. The first result was the official opening of the Joint Research Laboratory on Superconductivity and Bioelectronics in Shanghai in October 2010.

Japan

Prof. Sebastian M. Schmidt, member of the Board of Directors, headed a delegation from Jülich that visited Japanese research institutions in the fields of supercomputing and solid state research in April 2010. Talks identified opportunities for cooperation including the construction of supercomputers with the Japanese supercomputing centre RIKEN and collaboration in neutron research with J-Parc (Japan Proton Accelerator Research Complex). However, J-Parc suffered severe damage as a result of the catastrophic earthquake in March 2011. Forschungszentrum Jülich pledged to assist and support its Japanese colleagues in J-Parc in every conceivable form. Prof. Bachem offered the operators of RIKEN the use of the infrastructure of the European supercomputing organization PRACE to help them overcome their problems.

Multillateral Alliances in Europe

EERA – Accelerating the development of new energy technologies | In November 2010, the European Energy Research Alliance (EERA) officially announced the launch of a programme for separating carbon dioxide in conventional power plants and storing this greenhouse gas. Scientists at Forschungszentrum Jülich are working on this EERA programme as well as on other EERA programmes on photovoltaics and in the area of bioenergy. EERA was founded in 2008 as an alliance of ten of the leading energy research organizations in Europe. The objectives include joint research initiatives to accelerate the development of new energy technologies.
www.eera-set.eu

EIMRA – Clean energy thanks to European membrane research | Improving industrial energy efficiency and simultaneously reducing the emission of carbon dioxide is also the objective of the European Inorganic Membrane Research Alliance (EIMRA) set up in 2010. The alliance aims to advance research on ceramic membranes and to accelerate the transfer of results to industrial applications. These applications include the separation of carbon dioxide in fossil power plants and the production of hydrogen and liquid fuels from renewable sources. EIMRA brings together leading European groups in the area of membrane technology: the Energy Research Centre of the Netherlands (ECN), the Risø National Laboratory for Sustainable Energy in Denmark (DTU), the Flemish Institute for Technological Research in Belgium (VITO), SINTEF in Norway, and Forschungszentrum Jülich in Germany.

EIT – the KIC for climate protection | Forschungszentrum Jülich is involved in the new European Institute of Innovation and Technology (EIT). With the "Climate KIC" initiative (KIC = Knowledge and Innovation Community), the EU aims to improve its competitiveness in climate protection and in adapting to climate changes. The four priorities are measuring and modelling climate changes, reducing emissions in cities, adapting the water management system, and developing zero-carbon production systems. In February 2011, EIT, the European Commission and Climate KIC signed a corresponding framework agreement. At the same time, funding totalling € 6 million was granted for the first project phase. The climate initiative comprises sixteen European universities as well as research institutes, companies and regions. Jülich brings its expertise in systems research and technological development as well as in plant research to the table. http://eit.europa.eu/kics1/climate-kic.html

TEC – Continued cooperation for ITER | Forschungszentrum Jülich and its partners in the Trilateral Euregio Cluster (TEC) signed an agreement in July 2010 in Jülich on consolidating joint research for the ITER fusion experiment. Scientists will pool their know-how in order to develop materials for the wall elements in the plasma chamber of ITER. These must withstand the extreme conditions in ITER caused by neutrons from the fusion process and extremely hot plasma with a temperature of 100 million degrees.

MAO-ROBOTS – EU project for improved plastics | Polyolefins are the most important class of industrial plastics. They include the well-known polyethylene and polypropylene. To optimize them by improving their properties and to pave the way for new specialized materials are the goals that Jülich researchers are pursuing in the EU project MAO-ROBOTS (Methylaluminoxane (MAO) activators in the molecular polyolefin factory). Three research institutions and four top industrial enterprises from Germany, the UK, Finland and the Netherlands are involved in the interdisciplinary project. The European Union has granted the four-year project € 3.1 million, of which € 1 million is earmarked for research at Jülich.

Sharing Knowledge – Facts & Figures

Whoever shares their knowledge wins in so many ways. Forschungszentrum Jülich works with numerous partners from science and industry on both a national and international level and it does so to the benefit of all involved. In many of these joint projects, Jülich scientists are responsible for the coordination.

● Nationally funded projects coordinated by Forschungszentrum Jülich (examples)

Title	Funded by	Contract volume Jülich
HGF Alliance MEM-BRAIN (MEMBRANE)	HGF	€ 11,085,000
HGF Systems Biology Initiative; health network The human brain model: Connecting neuronal structure and function across temporal and spatial scales	HGF	€ 4,348,800
Device & Circuit Performance Boosted through Silicon Material Fabrication (DECISIF)	BMBF	€ 1,598,921
New adsober materials for thin-film solar cells with nanoparticles made of materials with unlimited availability (innovation alliance photovoltaics) (NADNuM)	BMBF	€ 1,320,731
Corynebacterium: Improvement of flexibility and fitness for industrial production (FlexFit)	BMBF	€ 1,257,056
Virtual Institute for Portable NMR (VIP-NMR)	HGF	€ 889,500
Virtual Institute “Inverse Modelling of Terrestrial Systems” (INVEST)	HGF	€ 885,000
Virtual Institute for Biological Structural Research (VIBS)	HGF	€ 720,000
Systems biology characterization of the energy budget of Corynebacterium glutamicum (SysEnCor)	BMBF	€ 545,653
Living with undesired co-habitants: Plant and animal answers to bacterial invasions – subproject 1 (ERA-NET ERASysBio+)	BMBF	€ 544,932
Project alliance: “Climate protection: Glass-foil combination for horticulture”; subproject “System test, coordination”; energy savings of 50 % for horticulture in greenhouses using new combinations of glass and foil as roofing	BMBF	€ 498,769
Biodosimetry: A systems biology approach for radiation biodosimetry and the analysis of individual radiation sensitivity; funding initiative radiation research network of competence; maintaining competence in radiation research	BMBF	€ 359,968
Development of a high-energy electron cooler for hadron physics experiments at COSY and HESR; HRJRG – Helmholtz-Russia Joint Research Group (IVF)	HGF	€ 359,760
Indo-German Partnership: Imparting drought stress tolerance to crop plants by heterologous transfer of high-altitude plant protection mechanisms	BMBF	€ 307,678
Grid integration of electrified drive systems into existing and future energy supply structures (NET-ELAN)	BMWi	€ 305,804

● Important national collaborative projects 2010 (examples)

Title	Funded by	Contract volume Jülich
Construction of a petaflop computer, federal state funding	MWMTV	€ 44,200,000
Construction of a petaflop computer, funding through the Gauss Centre	BMBF	€ 42,423,000
Transregional Collaborative Research Centre 32	DFG	€ 16,000,000
Development and testing of prototype components for ITER at Forschungszentrum Jülich	BMBF	€ 11,659,446
Kompetenzverbund Nord (KVN); increasing expertise in electrochemistry for electromobility	BMBF	€ 11,331,100
HGF Alliance MEM-BRAIN (MEMBRANE)	HGF	€ 11,085,000
Platform for translational neurological research based on the combination of ultrahigh-field magnetic resonance and positron emission tomography (development of a 9.4 tesla PET hybrid system)	BMBF	€ 9,900,000
German Research School for Simulation Science (GRS)	HGF	€ 6,200,000
Modernization of Jülich's centre of excellence in nuclear research	MWMTV	€ 5,000,000
HGF Systems Biology Initiative; health network The human brain model: Connecting neuronal structure and function across temporal and spatial scales	HGF	€ 4,348,800
Fuel processing technology with BTL and reformer fuel cell systems (formerly EFFESYS)	BMWi	€ 4,104,000
Helmholtz Alliance for Mental Health in an Aging Society (HelMA)	HGF	€ 1,233,000

In 2010, Forschungszentrum Jülich was involved in 222 nationally funded projects, including a good 100 alliances with several partners; 15 of these alliances were coordinated by Forschungszentrum Jülich.

● Collaborative research centres involving Jülich

2003	11
2004	14
2005	12
2006	14
2007	10
2008	18
2009	15
2010	12

International EU Cooperations

● Four EU projects were coordinated in 2010 by Forschungszentrum Jülich ("Co-ordinated collaborative projects")

- NASAOTM (energy research)
  Scientific head
  Dr. Wilhelm Meulenberg
- RECONCILE (climate research)
  Scientific head
  Dr. Marc von Hobe
- GARNICS (plant research)
  Scientific head
  Dr. Hanno Scharr
- HOPSA (supercomputing)
  Scientific head
  Dr.-Ing. Bernd Mohr

Furthermore, scientists from Forschungszentrum Jülich coordinated three EU infrastructure projects

- PRACE (supercomputing)
  Scientific head
  Dr. Thomas Eickermann
- PRACE1IP (supercomputing)
  Scientific head
  Dr. Thomas Eickermann
- ESMI (soft matter)
  Scientific head
  Dr. Godehard Sutmann

● Involvement of Forschungszentrum Jülich in EU programmes within the Seventh Framework Programme

EU programme	Number of approved projects	EU funding (thousands of euros)
Health	1	120
Food, Agriculture and Biotechnology	1	40
Information and Communication Technologies	2*	760
Nano, Materials and Production	1	220
Energy	1	700
Environment	1	1,330
Socio-economic Sciences and Humanities	1	
Euratom (including Training Fellowships (EIF))	1	125
Miscellaneous in FRP7 (Eranet, INTAS, etc.)	3	1,415
FRP7 total	**12**	**4,710**

* of which in 2010: 1

● EU-funded projects involving Jülich – funding in excess of € 1 million (selection)

Title	Contract volume Jülich
PRACE1IP	€ 3,852,590
HPC for Fusion (HPC-FF Systems): A Dedicated European High-Performance Computer for Fusion Applications	€ 3,600,000
POLPBAR	€ 1,689,900
RECONCILE: Reconciliation of essential process parameters for an enhanced predictability of arctic stratospheric ozone loss and its climate interactions	€ 1,635,728
CILIA	€ 1,633,310
SOFC600 – SOFC for Operation at 600 °C – IP	€ 1,086,313
NMI3 new	€ 1,078,820
DEISA2	€ 1,045,000
PATHOGENOMICS ERA-NET Coord. Action	€ 1,022,599
CARBOWASTE: Treatment and Disposal of Irradiated Graphite and Other Carbonaceous Waste	€ 1,003,757
MAO-ROBOTS: Methylaluminoxane (MAO) activators in the molecular polyolefin factory	€ 1,001,862

Cooperation with Industry

● Number of industrial collaborations

Year	National	International	Total
2004	201	83	284
2005	190	123	313
2006	222	103	325
2007	151	77	228
2008*			
2009	264	60	324
2010	260	65	325

*2008 not shown due to change of data system

● Important industrial collaborations for Forschungszentrum Jülich in 2010 (examples)

Project	Industrial partner
9.4 tesla/PET hybrid system for brain research	Siemens
ADELHEID, Reformers for fuel cell technology, further development for industrial manufacturing techniques	Airbus Deutschland, Presswerk Struthütten, GSR Ventiltechnik, Thomas Magnete, FRIGOBLOCK Grosskopf
ExaCluster Lab (ECL), Jülich Open Innovation Lab for Cluster Supercomputing Design and Evaluation	INTEL and PARTEC
Creation of an Exascale Innovation Center (EIC)	IBM
Liquid detector system EMILI	Emisens
Genetic algorithms for liquid detergent formulation	Henkel
GLASSeal, cost savings and optimization of glass sealant tapes for sealing in SOFC technology	Kerafol GmbH
New horizons for Gluconobacter oxydans strain development: fundamental studies on central metabolism, respiration and regulation using DNA microarrays, proteomics and metabolome-based carbon flux analysis	DSM Nutritional
Novel phenotypic screens with a focus on novel root screens in rice using soil-based 2D rhizotrons	BASF PlantSci
Testing the effectiveness of a tracer for the diagnosis of Alzheimer's disease using PET	Bayer Schering Pharma AG
DECISIF, Development of fast and economic electronic components	Globalfoundrier

The 9.4 tesla magnetic resonance tomograph is up to six times more powerful than conventional devices and about 200,000 times stronger than the Earth's magnetic field. Brain researchers want to use this device in the future to investigate the specific mechanisms of neurodegenerative diseases on the molecular level.

LEDs in different colours cast light on the black surface of a solar cell. The set-up is designed to help find out which parts of the spectrum of sunlight are utilized particularly well. Solar cells for integration into house façades are being developed by Malibu GmbH – a joint venture between energy company E.ON and window manufacturers Schüco. Malibu backs thin-film technology made in Jülich. Together, the research partners are developing the production processes for tandem cells combining an amorphous and a microcrystalline silicon layer with the aim of increasing efficiency. As an industrial partner, Malibu finances personnel at Forschungszentrum Jülich. The cooperation also receives funding within the framework of a project for the federal state of North Rhine-Westphalia.

Cereal plants in a phenotyping facility at the Institute of Bio- and Geosciences. The structure and material flows as well as other properties of the root system are determined quantitatively under real conditions. One of the aims is to aid the breeding of new crops.

Unique in Europe: The Bioeconomy Science Center

In a future bioeconomy, plants are to provide us with sufficient foodstuff, biobased materials, chemicals and fuel. How this can be achieved on a sustainable basis is what scientists from Forschungszentrum Jülich and the universities of Bonn, Düsseldorf and Aachen are investigating in the Bioeconomy Science Center (BioSC), which was founded in 2010. Fifty-four institutes with around 1,200 employees conduct joint research here on the key topics of an environmentally friendly economy based on renewable raw materials. In doing so, they consider climate protection and adapting to climate change, as well as economic, ecological and social dimensions. For example, they are investigating the extent to which such a bioeconomy would be economically viable and socially acceptable.

With its broad range of subjects and its infrastructure, BioSC is the first consortium in Europe that is in a position to take a closer look at such complex relationships in an interdisciplinary manner. Prof. Ulrich Schurr from Forschungszentrum Jülich, one of the founding directors of BioSC, uses an example to explain how this is done. “When an engineer from Aachen, for instance, is planning a new method for processing plant biomass, the partners from Bonn can grow this biomass sustainably, while scientists in Düsseldorf and Jülich can optimize the plant properties, and economists can investigate the criteria which make the process economic and determine the social aspects that need to be addressed.”

The four research priorities of BioSC are as follows:

- Sustainable plant bioproduction and resource conservation
- Microbial and molecular conversion of matter
- Process engineering of renewable raw materials
- Economy and social implications

Together, the BioSC partners make use of existing technology platforms – from genetic analysis and field tests to supercomputing.

They are also establishing integrated postgraduate studies for the bioeconomy, which aim to safeguard the interdisciplinary training of specialists. In order to ensure that research findings are quickly implemented in practice, the Bioeconomy Science Center aspires to work closely with medium-sized enterprises and globally active companies in industrial and threshold countries.

“Providing the world’s growing population with enough food, medicine, renewable raw materials and energy carriers while ensuring effective climate protection is the biggest challenge of the 21st century.”

Taken from the federal government’s High-Tech Strategy for Germany

Exascale – Performing Calculations a Thousand Times Faster

A quintillion is a “one” followed by eighteen zeros. This is how many arithmetic operations future supercomputers will be capable of performing every second. In Jülich – in cooperation with partners from industry – the foundation for just this is being laid. The aim is to create such exascale computers within the next ten years, computers that can perform calculations a thousand times faster than the fastest supercomputers today.

> “Model simulations and scenarios provide a central knowledge and decision-making basis for climate protection, adaptation, and energy supply.”
>
> Taken from the federal government’s High-Tech Strategy for Germany

However, breaking another record is not the only thing that drives the scientists. Exascale computers are urgently needed for a number of tasks, including simulating how the climate is changing, how new electronic components function or how fuel cells can be improved. “Exascale is the ultimate challenge for supercomputing worldwide. This project is decisive in terms of the options that Germany and Europe can offer science and industry in the future in this field,” said Prof. Sebastian M. Schmidt, member of the Board of Directors, when signing an agreement with IBM in March 2010. Building on a technology partnership that has grown over several years, IBM and the Jülich Supercomputing Centre (JSC) have agreed to set up a joint **Exascale Innovation Center** at sites in Jülich and Böblingen. The centre will work on the development of hardware and software for an exascale high-performance computer until 2020. A prototype is planned for 2015. “Energy efficiency is the most pressing problem that must be solved on the way towards an exaflop supercomputer,” says Prof. Thomas Lippert, director of JSC. Jülich has already proven its expertise when it comes to fast computers with minimum energy consumption in developing QPACE, which was listed at the end of 2009 as the most energy-efficient supercomputer in the world.

The IT companies Intel and ParTec also rely on Jülich’s experience in supercomputing. In May 2010, they signed an agreement with Forschungszentrum Jülich for a joint ExaCluster Laboratory. This laboratory will develop operating systems, software tools and simulation software for exascale cluster computers. Cluster computers are constructed modularly from a large number of cheap standardized hardware components. “Forschungszentrum Jülich plays a leading role in driving research forward in the field of supercomputing in Europe,” said Kirk Skaugen, vice president and general manager of the Intel Data Center Group, when signing the agreement. “What tipped the scales in terms of deciding to cooperate with Forschungszentrum Jülich was its past successes in the area of research and development.”

Signing of the agreement for a joint Exascale Innovation Center by representatives of Forschungszentrum Jülich and IBM (left to right: David Jursik, Vice President Worldwide Deep Computing Sales, IBM Systems & Technology Group; Dirk Wittkopp, Vice President and Director IBM Research and Development in Böblingen; Prof. Thomas Lippert, director Jülich Supercomputing Centre; Prof. Sebastian M. Schmidt, member of the Board of Directors, Forschungszentrum Jülich)

Jülich Aachen Research Alliance (JARA)

Forschungszentrum Jülich and RWTH Aachen University have always cooperated closely. In order to pool expertise in selected scientific areas, the Jülich Aachen Research Alliance (JARA) was set up in August 2007. Today, JARA has more than 4,000 employees and an annual budget exceeding € 350 million. The core areas of JARA are the four sections:

- JARA-BRAIN: Translational Brain Medicine
- JARA-FIT: Fundamentals of Future Information Technology
- JARA-HPC: High-Performance Computing
- JARA-ENERGY

Every year, more than 400 PhD students pursue studies in the JARA institutes. New training programmes, such as that of the "clinical scientist" and the "Master of Simulation Sciences" have also been established.

● Selected international collaborations

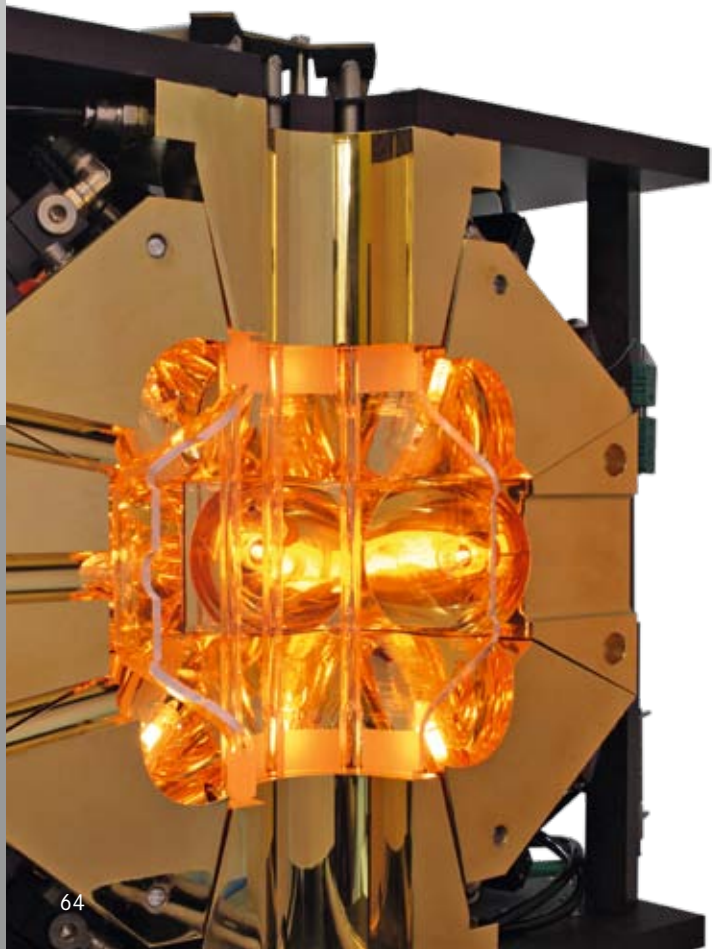
Area	Topic	Partner
JARA-ENERGY	Electron microscopy	AGH University of Science and Technology, Krakow
JARA-HPC	Expanded cooperation with ORNL, workshop with JSC, GRS, RWTH in preparation	Oak Ridge National Laboratory (ORNL), Department of Energy (DoE)
JARA-HPC	JSC: Coordination of the first PRACE implementation project PRACE-1IP	18 other European supercomputing centres
JARA-HPC	Creation of an ExaCluster Laboratory (ECL)	Intel, ParTec
JARA-HPC	Creation of an Exascale Innovation Center (EIC)	IBM
JARA as a whole		Polish research institutions

● The number of joint appointments of professors (salary grade W) made by RWTH Aachen University and Forschungszentrum Jülich increased from 11 in 2006 to 28 in 2010.

● The number of joint publications within the Jülich Aachen Research Alliance increased more than three times over from 150 in 2009 to 454 in 2010.

They can be broken down as follows:

JARA-BRAIN	84
JARA-FIT	285
JARA-HPC	67
JARA-ENERGY	18



A furnace with halogen lamps in the laboratory at the Institute of Energy and Climate Research. The heat-producing halogen lamps can be activated individually. This allows rapid and extreme temperature fluctuations to be simulated, which are relevant in practical applications – for example, inside power plant turbines.

Improved Assessment of the Effectiveness of Tumour Treatment – Thanks to JARA-BRAIN

Relatively rare but life threatening are brain tumours that develop from the supporting cells in the brain, the glial cells. Soon, doctors should be in a position to tell much faster whether the treatment of such gliomas with chemotherapy and radiation has been effective or not. This was suggested by a case study conducted by the JARA-BRAIN research alliance.

The FET-PET technique developed by Jülich scientists was tested in this study. In cooperation with researchers from RWTH Aachen University, they investigated in a clinical study initiated by the Jülich Aachen Research Alliance (JARA) whether the technique is suitable for assessing the effectiveness of treatment at an early stage. Only seven to ten days after treatment, FET-PET can show how much active tumour tissue is still present in the brain. Such were the results of the JARA study involving twenty-two patients, which ended in summer 2010. The new technique therefore provides results much faster than magnetic resonance imaging (MRI), which has been used in the past to monitor treatment (Int. J. Radiation Oncology Biol. Phys, doi: 10.1016/j.ijrobp.2010.01.055).

The team headed by Prof. Karl-Josef Langen from the Institute of Neuroscience and Medicine at Forschungszentrum Jülich and Priv.-Doz. Dr. Marc Piroth from Aachen University Hospital traced tumour cells using a radioactively labelled amino acid – O-(2-[18F] fluoroethyl)-L-tyrosine or FET for short. FET is injected into patients before and after cancer treatment and absorbed preferentially by tumour cells. Using positron emission tomography (PET), the radioactive molecules can be precisely located, therefore also uncovering the remaining cancer cells.

In this way, doctors can determine whether tumour activity has decreased after treatment. If the tumour cells absorb less and less of the radioactive amino acid, the treatment is effective. The advantage is that FET-PET allows the biological activity of the cancer cells to be observed directly. In contrast, MRI allowed a standard monitoring procedure that only made the structural changes in the brain visible. But these can be deceptive. The cancer treatment causes the blood-brain barrier to become temporarily more permeable. This can lead to an MRI image that looks as though the tumour is growing again. This in turn can lead to overtreatment and thus to unnecessary stress for patients, explain JARA researchers. Based on their results so far, they therefore favour the additional use of FET-PET to assess treatment. However, further more comprehensive studies are still required. In the JARA-BRAIN alliance, which is the only brain research alliance between a university and a national research centre in Germany, these studies are already under way.

Jülich Project for the Wendelstein 7-X Fusion Experiment Successfully Completed

The Max Planck Institute of Plasma Physics is currently constructing the Wendelstein 7-X nuclear fusion experiment in Greifswald. Scientists hope to use this to answer the question of whether the chosen principle of a stellarator is a viable alternative to the tokamak concept for a future fusion power plant. The tokamak has chalked up a number of successes to date.

Hot plasma, which will one day provide energy through nuclear fusion, is contained by a magnetic field generated by superconducting coils. The superconducting electrical connections between these coils is also an important component in the Greifswald stellarator.

With a budget of € 30 million, most of which came from EU funds, and their experience gained in Jülich's in-house fusion experiment TEXTOR, Jülich scientists developed a system of complex supply lines – known as a bus bar system – for this purpose. Using a 1:1 model, they tested the joints in Jülich under the same conditions expected later in the Greifswald fusion experiment. And they were successful. The joints withstood a temperature of -269 °C, conducted electricity with no resistance and withstood a high voltage of up to 13,000 volts as well as extremely strong mechanical stresses.

Wendelstein 7-X module 5 during installation of the bus bar system.

Jülich Know-How in Industry and Society

Jülich research provides answers to fundamental questions. It also drives innovations worth their weight in gold which benefit both industry and society. A steady flow of new patent applications and numerous licensing agreements testify to this.

Licences

- Number of licences 2010

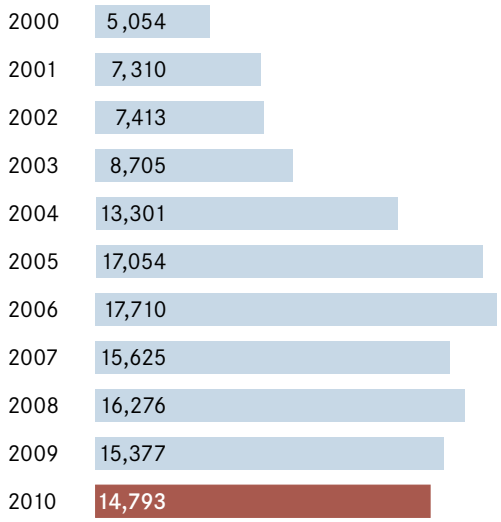
Total	138	
New	12	
Discontinued	43	
Total percentage foreign	36	(= 26.1 %)
Percentage USA (most important partner country)	13	(= 9.4 %)
Percentage SMEs	100	(= 72.5 %)

- Income from licences 2010

€ 1.4 million

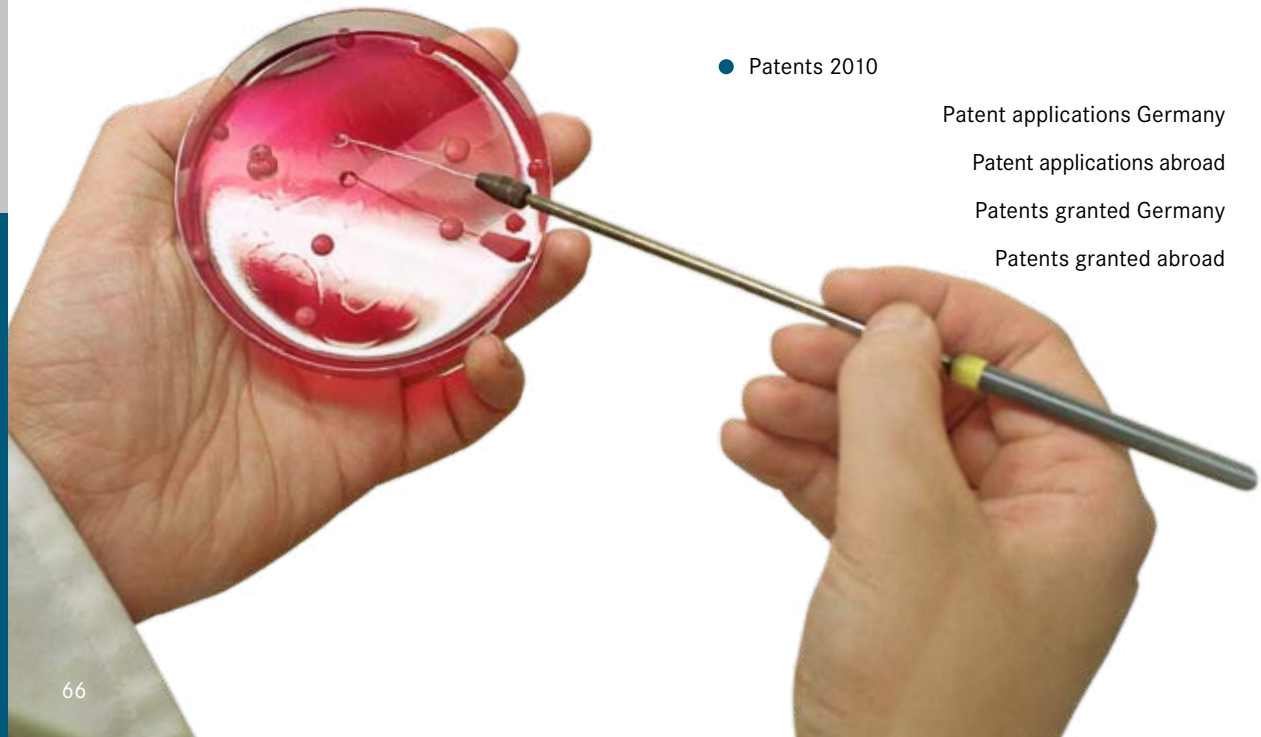
Patents

- Total number of protective rights 2010 (Patents, patent applications and utility models in Germany and abroad)



- Patents 2010

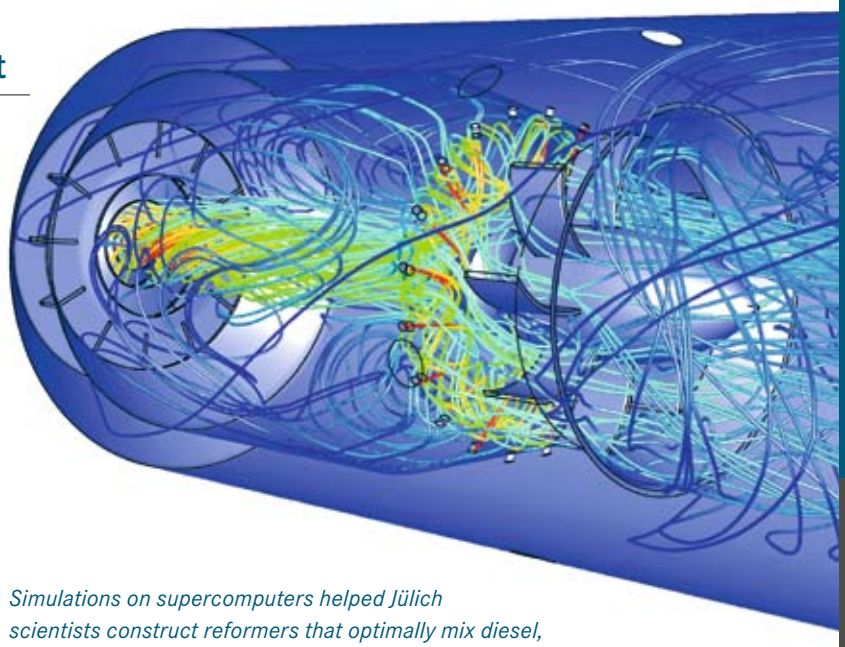
Patent applications Germany	43
Patent applications abroad	33
Patents granted Germany	10
Patents granted abroad	61



Research for Practical Applications

More efficient energy technologies, faster analysis of gases, a new tool for nanotechnologists – three recent examples highlight how industry and society profit from the know-how at Forschungszentrum Jülich.

Reformers Ready for the Market



Simulations on supercomputers helped Jülich scientists construct reformers that optimally mix diesel, air and water vapour. Here, the different colours represent the velocities of the air streams fed into the mixing chamber, ranging from slow (blue) to moderate (green) to fast (yellow and red).

Fuel cells can generate electricity for aircraft, trucks and ships efficiently, reliably and with low emissions. They are therefore a beneficial alternative to current generators and alternators. When used in aircraft, they have added advantages. Water created as a byproduct can be used on board as process water and the off-gases from the fuel cells can be used to decrease the oxygen content in the kerosene tank. This means that water tanks and the fuel tank inerting system are no longer needed, which reduces the take-off weight and thus the fuel consumption of the aircraft.

Fuel cells obtain energy from a hydrogen-containing gas, which can be generated from kerosene or diesel using reformers. Scientists at Forschungszentrum Jülich are not only improving fuel cells but also these reformers. Over the last few years, for example, they have succeeded in significantly increasing the lifetime of reformers. The devices can now generate fuel in a highly efficient manner for more than 2,000 operating hours thanks to a patented design for which simulations were performed on the Jülich supercomputers.

"Now, we are developing production techniques for the reformers in cooperation with partners from industry. These techniques also have the potential for commercialization, taking economic aspects into consideration," says Prof. Ralf Peters. The Jülich energy researcher is head of the ADELHEID project, which aims to get inventions out of the laboratory and into the air. Partners from industry are Presswerk Struthütten, GSR Ventiltechnik, Thomas Magnete and FRIGOBLOCK Grosskopf. Peters is convinced that "The project is a good example of a win-win situation. As a government-funded research institution, we bring a promising prototype to the table – a reformer of the eighth generation. Presswerk Struthütten contributes an innovative welding process for sheet metal that does not just pave the way for economic mass production but also for lightweight construction. Lightweight construction, in turn, helps to significantly decrease the reformer's start-up times when it is in operation." The other industrial partners contribute their expertise as automobile suppliers and apparatus engineers in the areas of valves, pressure vessels and pumps. "With our research, we are not just laying the foundation. We are going further and taking the necessary steps for application," says Prof. Detlef Stolten, director at the Institute of Energy and Climate Research, in summary.

Faster Analysis Using Nanoparticles

A sensitive analytical technique known as gas chromatography helps to analyse off-gases from industrial plants, to monitor production in refineries and in the pharmaceutical industry, and to identify climate-relevant hydrocarbons in the atmosphere. Forschungszentrum Jülich is working together with the medium-sized enterprise Chromatographie Service (CS) and the company Chemical Consulting Dornseiffer (CCD) to make gas chromatography faster and more accurate. Having been granted funding totalling € 200,000 in the middle of 2010 by the Federal Ministry of Education and Research (BMBF) within the KMU-innovativ funding initiative for nanotechnology (NanoChance), the partners have already scored first successes.

In a gas chromatographic analysis, the gaseous sample flows through fine tubes, the surfaces of which are coated with special substances, such as waxes or porous solids. The coated surface retains different molecules of the sample to various degrees. The result is that the sample separates into its components, which can then be identified. Such analyses usually take a few minutes, but in some cases they can last for up to an hour.

The scientists from industry and from Jülich are investigating surface coatings created from tiny oxide-ceramic particles measuring no more than a nanometre. Within a few months, they successfully developed coatings from such nanoparticles which are on a par with conventional coatings in terms of their separation efficiency. However, the scientists are convinced that the full potential of the coatings has not yet been exploited and they believe that chromatographic analyses will be possible in a matter of seconds in the future. With respect to accuracy, project leader Dr. Volker Lorbach is confident of progress: "By using nanotechnology in the field of chromatography, we will probably be able to recognize substances in certain cases that have been overlooked by conventional methods in the past," says the expert from CS.

Prof. Andreas Wahner, director at the Institute of Energy and Climate Research, hopes that the results of the research project will allow the composition of the Earth's atmosphere to be determined at shorter intervals on measurement flights in the future. Jülich atmospheric researchers have been working with nanoparticles for some time and they have the ability to characterize them precisely. CCD has provided tailor-made nanoparticles for the last ten years for research purposes, particularly in the areas of electroceramics and catalysis. CS has been developing and producing separation columns for chromatography for the last twenty-five years. For this reason, Helmut Römer, managing director of CS, takes the name of the BMBF funding initiative "NanoChance" at face value. "In this collaborative project, there is potential know-how that is rarely rivalled elsewhere. As a medium-sized enterprise, this puts us in a position to develop innovations that would otherwise only originate in large corporations."

> "Germany needs to increase the long-term participation of SMEs in R&D activities and enhance the innovative strength of small and medium-sized companies."
>
> Taken from the federal government's High-Tech Strategy for Germany

Thanks to a research project involving Jülich scientists and industry, the composition of the atmosphere will be measured more accurately and at shorter intervals on measurement flights in the future.

Four-tip scanning tunnelling microscope: as compact as a normal scanning tunnelling microscope with one tip.

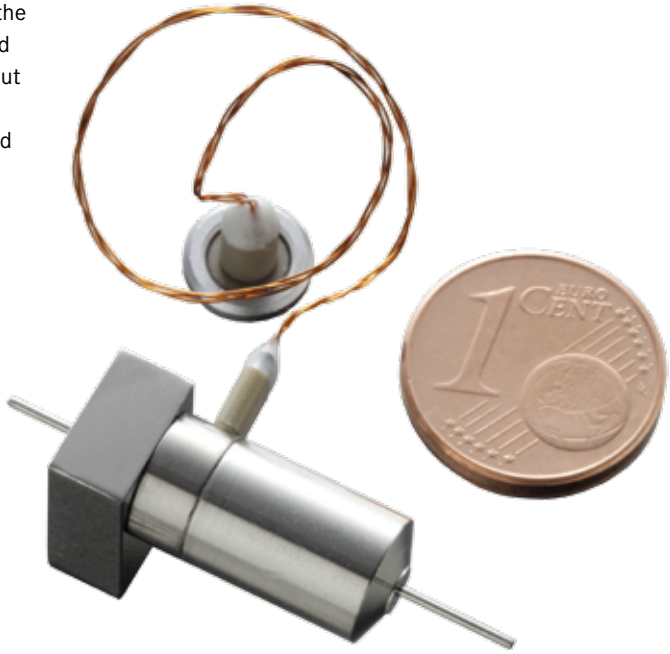
Mechanism for Analyses in the Nanoworld

According to manufacturers' information, more than a thousand consumer products have already been nanotechnologically optimized. And today "microelectronics" has become "nanoelectronics". Many electronic components in information technology no longer measure a few micrometres; instead they have shrunk to nanometre dimensions. The rise of nanotechnology is closely linked to the discovery of the scanning probe microscope, which beginning in the 1980s brought with it the aspiration of actually arranging and using nanoscale objects in a targeted manner for the first time. In their research, Jülich scientists from a variety of disciplines also relied more and more on scanning tunnelling and atomic force microscopy. Both techniques involve a tip that scans the surface of materials, so to speak, and thus makes the tiniest of structures on these materials visible.

For several years, Prof. Bert Voigtländer and his team from Jülich's Peter Grünberg Institute have been pursuing the idea of expanding the potential of scanning tunnelling microscopy and of using it to measure the electrical properties of nanowires and other nanostructures. "In order to perform current and voltage measurements on nanostructures, and to determine, for example, how the flow of current is altered by defects on an atomic level, we need four tips rather than just one," says Voigtländer. The physicist continues, "However, when we attempted to equip a scanning tunnelling microscope with four tips, we came up against a number of difficulties." The main problem was that the mechanism for bringing the tips close to the sample also required quite a lot of space, which meant that the four tips could not be placed as closely together as would have been necessary for many types of analyses.

However, the Jülich scientists succeeded in developing a completely new drive mechanism, which is extremely compact with a diameter of around two-and-a-half millimetres. This allows each tip to be brought as close as a few micrometres away from the surface of the sample. In contrast to the technology used up to now, this new mechanism allows the tips to be positioned smoothly and without vibrations. The new mechanism – named the "koala drive" by the scientists – can also be used in a vacuum, at low temperatures or in high magnetic fields. It allows a four-tip instrument to be constructed that takes up no more space than a conventional scanning tunnelling microscope with one tip.

A patent application has since been filed for the koala drive. The Jülich scientists presented their progress in 2010 at events such as the Hannover Messe and in March 2011 at the Annual Meeting of the German Physics Society (DPG). They were met with huge interest from companies in industry who want to use this Jülich technology commercially.



Appendix

Finances

Investments in science and research secure our future. Financing from public funds makes it possible to conduct the independent preliminary research that is essential to ensure sustainable development. In addition to this, Forschungszentrum Jülich also aims to generate income from licences with its industrially oriented research.

Balance sheet

Subsidies from the federal government and the state of North Rhine-Westphalia make up by far the largest part of Forschungszentrum Jülich's income. In addition, Jülich also receives third-party funding from industry, project funding from the federal and state governments, and research funds from the European Union.

Balance sheet 2010 (millions of euros)

Assets	2010	2009
A. Fixed assets	**439.6**	**422.0**
I. Intangible assets	2.8	2.1
II. Tangible assets	436.6	419.7
III. Financial assets	0.2	0.2
B. Current assets	**629.4**	**624.2**
I. Inventories	17.5	17.8
II. Accounts receivable and other assets	19.4	31.5
III. Government equity to balance the books	563.9	570.6
IV. Cash on hand and on deposit with the Deutsche Bundesbank, cash at credit institutions, cheques	28.6	4.2
C. Accruals and deferrals	**65.4**	**75.7**
Total assets	1,134.4	1,121.8

Liabilities	2010	2009
A. Equity capital	**0.5**	**0.5**
B. Special items for subsidies	**534.5**	**532.0**
I. on fixed assets	439.1	421.5
II. on current assets	95.4	110.5
C. Provisions	**554.3**	**554.2**
I. Decommissioning and disposal of nuclear installations	495.7	504.3
II. Pensions and miscellaneous	58.6	49.9
D. Accounts payable	**44.6**	**34.4**
E. Accruals and deferrals	**0.5**	**0.7**
Total liabilities	1,134.4	1,121.8

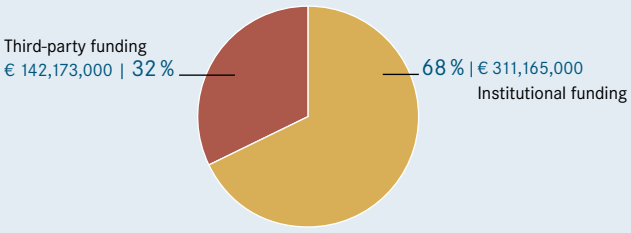
Profit and loss account

The profit and loss account compares the revenue and costs of Forschungszentrum Jülich. The difference normally corresponds to the company profit or loss. In the case of Forschungszentrum Jülich, the shareholders are obliged to balance the books. Like institutional funding, this extra revenue is part of the additional subsidies. The profit and loss statement is therefore always balanced. Forschungszentrum Jülich generates significant revenue through project management activities, a large number of research and development projects, and the provision of research facilities. The remaining operating income mainly consists of income from the reserves put aside for the decommissioning of nuclear facilities.

Profit and loss statement 2010 (millions of euros)

	2010 millions		2009 millions	
Income from subsidies		384.7		462.2
Other subsidies		311.1		327.7
from federal government	273.2		286.0	
from state government	37.8		41.7	
Third-party project funding		73.6		134.5
from federal government	47.5		38.8	
from state government	6.7		37.2	
from EU and others	19.4		58.5	
Revenues and other income		81.4		138.8
Revenues from research, development and the use of research facilities		11.2		12.9
Revenues from licensing and know-how agreements		1.6		2.2
Revenues from project management organizations		42.2		39.2
Revenues from infrastructure services and the sale of materials		13.3		12.4
Revenues from the disposal of fixed assets		0.4		0.6
Increase or reduction in the inventory of work in progress and services		0.3		-0.4
Other own work capitalized		1.0		0.8
Other operating income		11.3		71.0
Other interest and similar income		0.1		0.1
Allocations to special items for subsidies		-53.7		-116.8
Transferred subsidies		-42.8		-32.8
Income from subsidies, revenue and other income available to cover expenses		**369.6**		**451.4**
Personnel costs		237.8		230.0
General expenses		43.4		39.3
Material costs		21.7		20.3
Costs for energy and water		17.3		15.1
Costs for external research and development		4.4		3.9
Other operating costs		88.4		182.1
Remediation and environmental costs		7.3		110.9
Other costs for management and maintenance		42.8		41.4
Operating and administration costs		18.4		17.0
Costs for research activities		12.4		12.7
Other interest and similar costs		1.9		0.1
Non-recurring expenses		5.6		0.0
Depreciation on fixed assets		0.0		0.0
Depreciation on fixed assets		49.7		46.0
Income from liquidation of special items for subsidies		-49.7		-46.0
Total expenditure		**369.6**		**451.4**
Result of normal business activity/Annual result		**0.0**		**-0.0**

Budget 2010



Budget

In 2010, Forschungszentrum Jülich's third-party funding totalled € 145.2 million, representing a decrease of € 59.1 million compared to 2009 (€ 204.3 million). Third-party funding therefore decreased to the average level of the previous years. Most of this third-party income resulted from research and development activities for industry, the acquisition of funding from Germany and abroad, plus project management on behalf of the Federal Republic of Germany and the federal state of North Rhine-Westphalia. In addition, substantial income from third-party sources was generated through infrastructural services. Third-party funding also included subsidies of € 19.6 million which were passed on to the Institute Laue-Langevin in the form of payments to cover operating costs. Institutional funding in 2010 totalled € 311.2 million.

Budget 2010 (thousands of euros)

Research area	Structure of matter	Earth and environment	Health	Energy	Key technologies	Biotechnology	Infrastructure	Total
International funding	809	1,586	293	4,008	343	165	728	**7,932**
National project funding	601	4,625	1,145	15,109	8,253	1,439	4,530	**35,702**
DFG funding	220	995	138	689	1,596	62	466	**4,166**
Contracts, abroad	84	549	2	1,028	341	42	1,125	**3,171**
Contracts, Germany	491	587	617	8,198	2,057	615	11,887	**24,452**
Transferred subsidies	75	397	96	6,087	1,279		19,612	**27,546**
Project management organizations							42,204	**42,204**
Subtotal	**2,280**	**8,739**	**2,291**	**35,119**	**13,869**	**2,323**	**80,552**	**145,173**
Institutional funding								**279,521**
Dismantling projects								**31,644**
Total budget								**456,338**

Please note: This table does not include DFG earnings amounting to € 95,000 as they have been generated within the framework of private service contracts and therefore do not count as operating income of Forschungszentrum Jülich. Following the significant increase in national project funding last year for the installation of a petaflop computer, national project funding returned to its usual level in 2010. The new strategic orientation during the transition from the first round of programme-oriented funding (POF I) to POF II led to structural changes in the research areas.

Company Bodies

Forschungszentrum Jülich was established on 11 December 1956 by the German federal state of North Rhine-Westphalia as a registered association. On 5 December 1967, it was converted into a GmbH (limited company) with the Federal Republic of Germany and the state of North Rhine-Westphalia assuming the role of shareholders.

The Partners' Meeting is chaired by the Chairperson of the Supervisory Board. The Scientific and Technical Committee set up by the Supervisory Board prepares its resolutions on scientific and technical matters.

The Scientific and Technical Council is a company body that advises the Partners' Meeting, the Supervisory Board and the Board of Directors of Forschungszentrum Jülich on all scientific and important technical issues. It advises on and formulates resolutions concerning scientific and technical matters of fundamental importance and ensures that agreement is reached on these matters with the Board of Directors.

Supervisory Board

Ministerialdirigent
Dr. Karl Eugen Huthmacher (Chairman)
Federal Ministry of Education and Research

Staatssekretär
Helmut Dockter (Vice-Chairman)
Ministry of Climate Protection, Environment, Agriculture, Nature and Consumer Protection of the State of North Rhine-Westphalia

RBr Ernst-Christoph Stolper
Ministry of Climate Protection, Environment, Agriculture, Nature and Consumer Protection of the State of North Rhine-Westphalia

Dr. Arnd Jürgen Kuhn
Forschungszentrum Jülich, Institute of Bio- and Geosciences

MinR Dr. Knut Kübler
Federal Ministry of Economics and Technology

Prof. Dr. Alfons Labisch
Heinrich Heine University Düsseldorf

Prof. Dr. Angelika Merschenz-Quack
Aachen University of Applied Sciences

Dr. Johannes Mertens
Forschungszentrum Jülich, Institute of Neuroscience and Medicine

Ministerialdirigentin Dr. Gisela Otto
Federal Ministry of Finance

Dr.-Ing. Hermann Stelzer
Forschungszentrum Jülich, Central Technology Division

Dr. Beatrix Vierkorn-Rudolph
Federal Ministry of Education and Research

Scientific and Technical Committee

Dr. Beatrix Vierkorn-Rudolph (Chairperson)
Federal Ministry of Education and Research

Prof. Dr. Urs Baltensperger
Paul Scherrer Institute

Prof. Dr. med. Ulf Eysel
Ruhr University Bochum

Prof. Dr. Wolfhard Janke
University of Leipzig

Prof. Dr. Thomas Krieg
University of Cologne

Dr. Arndt Jürgen Kuhn
Forschungszentrum Jülich, Institute of Bio- and Geosciences

Prof. Dr. Angelika Merschenz-Quack
Aachen University of Applied Sciences

Prof. Dr. Stephan Paul
Munich University of Technology

MinR Klaus Sachs
Ministry of Innovation, Science, Research and Technology of the State of North Rhine-Westphalia

Prof. Dr.-Ing. Ernst M. Schmachtenberg
RWTH Aachen University

MinR Dr. Knut Kübler
Federal Ministry of Economics and Technology

Scientific and Technical Council

Chairman
Prof. Dr. U. Samm
Institute of Energy and Climate Research

Vice-Chairmen
Dr. M. Schiek
Central Institute for Electronics

Prof. Dr. A. Wahner
Institute of Energy and Climate Research

Additional members of the Main Committee
Prof. Dr. T. Brückel
Jülich Centre for Neutron Science/Peter Grünberg Institute

Prof. Dr. R. Freudl
Institute of Bio- and Nanosystems

Dr. G. Günther
Institute of Energy and Climate Research

Dr. C. Hanhart
Nuclear Physics Institute

Prof. P. Jansen
Jülich Supercomputing Centre

Dr. B. König
Institute of Complex Systems

Prof. Dr. Dr. T. Lippert
Institute for Advanced Simulation/Jülich Supercomputing Centre

Prof. Dr. R. Maier
Nuclear Physics Institute

Prof. Dr. R. Merkel
Institute of Complex Systems

Company Bodies

Dr. J. Moers
Peter Grünberg Institute

Dr. G. Natour
Central Technology Division

Prof. Dr. U. Pietrzyk
Institute of Neuroscience and Medicine

Prof. Dr. N. J. Shah
Institute of Neuroscience and Medicine

Dr. J. Stellbrink
Jülich Centre for Neutron Science

Prof. Dr. S. Tautz
Peter Grünberg Institute

Prof. Dr. H. Vereecken
Institute of Bio- and Nanosystems

Prof. Dr. A. Wahner
Institute of Energy and Climate Research

Additional members of the Plenum

Ms I. Adamchic
Institute of Neuroscience and Medicine

Prof. Dr. H.-J. Allelein
Institute of Energy and Climate Research

Prof. Dr. W. Amelung
University of Bonn

Prof. Dr. K. Amunts
Institute of Neuroscience and Medicine

Prof. Dr. A. Baumann
Institute of Complex Systems

Prof. Dr. T. Beck
Institute of Energy and Climate Research

Prof. Dr. S. Blügel
Peter Grünberg Institute/Institute for Advanced Simulation

Prof. Dr. D. Bosbach
Institute of Energy and Climate Research

Prof. Dr. M. Bott
Institute of Bio- and Nanosystems

Prof. Dr. T. Brückel
Jülich Centre for Neutron Science/Peter Grünberg Institute

Prof. Dr. G. Büldt
Institute of Complex Systems

Dr. M. Büscher
Nuclear Physics Institute

Dr. S. Caspers
Institute of Neuroscience and Medicine

Prof. Dr. H. H. Coenen
Institute of Neuroscience and Medicine

Prof. Dr. M. Diesmann
Institute of Neuroscience and Medicine

Prof. Dr. D. DiVicenzo
Peter Grünberg Institute/Institute for Advanced Simulation

Prof. Dr. J. K. Dhont
Institute of Complex Systems

Dipl.-Ing. H. Feilbach
Jülich Centre for Neutron Science

Dr. O. Felden
Nuclear Physics Institute

Prof. Dr. G. Fink
Institute of Neuroscience and Medicine

Dr. J. Fitter
Institute of Complex Systems

Dr. H. Fuchs
Institute of Energy and Climate Research

Dr. F. Gilmer
Institute of Bio- and Nanosystems

Dr. H. Glückler
Central Technology Division

Dr. F. Goldenbaum
Nuclear Physics Institute

Prof. Dr. G. Gompper
Institute of Complex Systems/Institute for Advanced Simulation

Prof. Dr. D. A. Grützmacher
Peter Grünberg Institute

Dipl.-Ing. E. Harren
Institute of Energy and Climate Research

Mr J. Heinen
Jülich Centre for Neutron Science

Dr. O. Holderer
Jülich Centre for Neutron Science

Dr. B. Holländer
Peter Grünberg Institute

Dipl.-Ing. C. Jebsen
Works Council

Prof. Dr. R. Koppmann
University of Wuppertal

Dr. A. Krämer-Flecken
Institute of Energy and Climate Research

Prof. Dr. J. Krug
University of Cologne

Dr. S. Küppers
Central Division of Analytical Chemistry

Frau Dipl.-Ing. H. Lippert
Central Division of Analytical Chemistry

Dr. D.E. Mack
Institute of Energy and Climate Research

Dr. P. Markewitz
Institute of Energy and Climate Research

Dr. D. Mayer
Peter Grünberg Institute

Prof. Dr. J. Mayer
Peter Grünberg Institute

D. Meertens
Peter Grünberg Institute

Prof. Dr. U.-G. Meißner
Nuclear Physics Institute/Institute for Advanced Simulation

Dr. P. Meuffels
Peter Grünberg Institute

Prof. Dr. M. Morgenstern
RWTH Aachen University

Prof. Dr. F. Müller
Institute of Complex Systems

Dr. D. Nicolai
Institute of Energy and Climate Research

Prof. Dr. A. Offenhäusser
Peter Grünberg Institute/Institute of Complex Systems

Prof. Dr. H. P. Peters
Institute of Neuroscience and Medicine

Dr. G. Pirug
Peter Grünberg Institute

Dr. S. Pust
Institute of Energy and Climate Research

Prof. Dr. U. Rau
Institute of Energy and Climate Research

Dr. U. Reimer
Institute of Energy and Climate Research

Prof. Dr. D. Reiter
Institute of Energy and Climate Research

Prof. Dr. D. Richter
Jülich Centre for Neutron Science/Institute of Complex Systems

Prof. Dr. M. Riese
Institute of Energy and Climate Research

Prof. Dr. J. Ritman
Nuclear Physics Institute

Prof. Dr. L. Schmitt
Heinrich Heine University Düsseldorf

Prof. Dr. C.-M. Schneider
Peter Grünberg Institute

Dr. B. Scholten
Institute of Neuroscience and Medicine

Prof. Dr. H. Schroeder
Peter Grünberg Institute

Prof. Dr.-Ing. J. Schröder
University of Duisburg-Essen

Prof. Dr. U. Schurr
Institute of Bio- and Nanosystems

Dr. W. Schweika
Jülich Centre for Neutron Science

Prof. Dr. N. J. Shah
Institute of Neuroscience and Medicine

Prof. Dr. L. Singheiser
Institute of Energy and Climate Research

Dr. T. Stöcker
Institute of Neuroscience and Medicine

Prof. Dr. D. Stöver
Institute of Energy and Climate Research

Prof. Dr. D. Stolten
Institute of Energy and Climate Research

Prof. Dr. H. Ströher
Nuclear Physics Institute

Prof. Dr. D. Sturma
Institute of Neuroscience and Medicine

Prof. Dr. Dr. P. Tass
Institute of Neuroscience and Medicine

Dr. B. Tetzlaff
Institute of Bio- and Nanosystems

Prof. Dr. B. Thomauske
Institute of Energy and Climate Research

Dr. H. Tietze-Jaensch
Institute of Energy and Climate Research

Prof. Dr. H. Vereecken
Institute of Bio- and Nanosystems

Dr. S. van Waasen
Central Institute for Electronics

Dr. E. von Lieres
Institute of Bio- and Nanosystems

Prof. Dr. A. Wahner
Institute of Energy and Climate Research

Prof. Dr. R. Waser
Peter Grünberg Institute

Prof. Dr. T. Weis
University of Dortmund

Dr. P. Weiss-Blankenhorn
Institute of Neuroscience and Medicine

Prof. Dr. J. Wessels
University of Münster

Prof. Dr. W. Wiechert
Institute of Bio- and Nanosystems

Prof. Dr. D. Willbold
Institute of Complex Systems

Prof. Dr. J. Winter
Ruhr University Bochum

Dr. D. Wortmann
Peter Grünberg Institute

Prof. Dr. K. Zilles
Institute of Neuroscience and Medicine

Organization Chart

Partners' Meeting
Chairman MinDirig Dr. K. E. Huthmacher

Supervisory Board
Chairman MinDirig Dr. K. E. Huthmacher

Board of Directors
Science; External Relations Prof. A. Bachem (Chairman of the Board of Directors)

- **Resource and Investment Strategy**
  Dr. A. Keßeler
- **Information and Communications Management**
  A. Bernhardt
- **JARA Office of the Secretary General**
  Dr. N. Drewes
- **Corporate Communications**
  Dr. A. Rother
- **Corporate Strategy**
  Dr. A. Haas

Staff Units

- **Office of the Board of Directors**
  Dr. T. Voß

Board of Directors
Scientific Division I Prof. S. M. Schmidt (Member of the Board of Directors)

- **Institute of Complex Systems**
  Prof. G. Büldt, Prof. J. K. G. Dhont, Prof. G. Gompper, Prof. R. Merkel, Prof. F. Müller (acting), Prof. A. Offenhäuser, Prof. D. Richter, Prof. D. Willbold
- **Nuclear Physics Institute**
  Prof. R. Maier, Prof. U.-G. Meißner, Prof. J. Ritman, Prof. H. Ströher
- **Institute for Advanced Simulation**
  Prof. S. Blügel, Prof. D. DiVincenzo, Prof. G. Gompper, Prof. T. Lippert, Prof. U.-G. Meißner
- **Institute of Neuroscience and Medicine**
  Prof. K. Amunts, Prof. H. H. Coenen, Prof. M. Diesmann, Prof. G. R. Fink, Prof. N. J. Shah, Prof. D. Sturma, Prof. P. Tass, Prof. K. Zilles
- **Jülich Centre for Neutron Science**
  Prof. D. Richter, Prof. T. Brückel
- **Peter Grünberg Institute**
  Prof. S. Blügel, Prof. T. Brückel, Prof. D. DiVincenzo, Prof. R. E. Dunin-Borkowski, Prof. D. A. Grützmacher, Prof. A. Offenhäuser, Prof. C. M. Schneider, Prof. S. Tautz, Prof. R. Waser
- **IT Services**
  F. Bläsen

As of: 1 June 2011

Scientific and Technical Council

Chairman Prof. U. Samm

Board of Directors

Scientific Division II Prof. Dr.-Ing. H. Bolt (Member of the Board of Directors)

Institute of Bio- and Nanosystems

Prof. M. Bott, Prof. U. Schurr, Prof. H. Vereecken, Prof. W. Wiechert

Institute of Energy and Climate Research

Prof. H.-J. Allelein, Prof. D. Bosbach, Prof. J.-F. Hake, Prof. U. Rau, Prof. D. Reiter (acting), Prof. M. Riese, Prof. U. Samm, Prof. L. Singheiser, Prof. D. Stöver, Prof. D. Stolten, Prof. B. Thomauske, Prof. A. Wahner

Institute of Molecular Enzyme Technology (HHUD)

Prof. K.-E. Jaeger

Institute of Bioorganic Chemistry (HHUD)

Prof. J. Pietruszka

Joint Scientific and Technical Facilities

Central Division of Analytical Chemistry

Dr. S. Küppers

Central Technology Division

Dr. G. Natour

Central Institute for Electronics

Dr. S. van Waasen

Project Management Organizations

Project Management Jülich

Dr. U. Schlüter

Project Management Organization Energy, Technology, Sustainability

Dr. B. Steingrobe

Board of Directors

Infrastructure Dr. U. Krafft (Vice-Chairman of the Board of Directors)

Personnel

Dr. M. Ertinger

Finance and Controlling

R. Kellermann

Purchasing and Materials

R.-D. Heitz

Law and Patents

C. Naumann

Organization and Planning

A. Emondts

Technology Transfer

Dr. R. Raue

Central Library

Dr. B. Mittermaier

Technical Infrastructure

Dr. G. Damm

Nuclear Services

Dr. G. Damm/R. Printz

Safety and Radiation Protection

Dr. R. Lennartz

Building and Property Management

M. Franken

Planning and Building Services

J. Kuchenbecker

Staff Units

Revision

A. Kamps

Contact Information

Would you like more information? If so, please do not hesitate to contact us ...

Corporate Communications
Head:
Dr. Anne Rother

Forschungszentrum Jülich GmbH
52425 Jülich
Germany
Tel. + 49 2461 61-4661
Fax + 49 2461 61-4666
info@fz-juelich.de
www.fz-juelich.de

Technology Transfer
Head:
Dr. R. Raue
ttb@fz-juelich.de

... come and visit us ...

We organize guided tours of Forschungszentrum Jülich for interested groups. Please contact our Visitor Service for more information.
Tel. + 49 2461 61-4662
besucher_uk@fz-juelich.de

... or request a copy of our free brochures:

You can order our publications free of charge or download them online at:
www.fz-juelich.de/portal/EN/Press/Publications/_node.html

How to find us:

By car

If you are coming from Aachen or Düsseldorf on the A 44 motorway, leave the motorway at the Jülich-West exit. At the first roundabout, turn left in the direction of Jülich. At the second roundabout, turn right (Westring) towards Düren. After approx. 5 km, turn left onto the L 253 and follow the signs for “Forschungszentrum”.

If you are coming from Cologne (Köln) on the A 4 motorway, leave the motorway at the Düren exit and turn right towards Jülich (B 56). After approx. 10 km, turn right and continue until you reach Forschungszentrum Jülich.

Using navigation systems

Enter your destination or street name as “Wilhelm-Johnen-Strasse”. From there, it is only a few hundred metres to the main entrance of Forschungszentrum Jülich – simply follow the signs. Forschungszentrum Jülich itself is not part of the network of public roads and is therefore not recognized by navigation systems.

By public transport

You can take the train from Aachen or Cologne (Köln) to Düren train station. From here, you should take the local train (“Rurtalbahn”) to the “Forschungszentrum” stop. The main entrance is about a fifteen-minute walk from here.

Since 1999, Forschungszentrum Jülich has displayed the Total E-Quality logo, which testifies to its equal opportunities personnel policy.

In 2010, Forschungszentrum Jülich became certified as part of the “audit berufundfamilie” initiative. Jülich has thus committed itself to continuously defining and implementing measures for improving the reconciliation of work and family life.

Publication Details

Publisher: Forschungszentrum Jülich GmbH | 52425 Jülich, Germany | Tel: + 49 2461 61-4661 | Fax: + 49 2461 61-4666 | Internet: www.fz-juelich.de Editorial Team: Dr. Wiebke Rögener, Annette Stettien, Dr. Anne Rother (responsible under German Press Law) Authors: Dr. Frank Frick, Dr. Wiebke Rögener, Brigitte Stahl-Busse Translation: Language Services, Forschungszentrum Jülich Graphics and layout: SeitenPlan Corporate Publishing GmbH Printers: Schloemer Gruppe GmbH Photos: PRACE (p. 10 top left), GENCI (p. 19 bottom right), ESS AB (p. 19 top left and p. 21), GRS (p. 46), Beate Kemnitz – IPP Greifswald (p. 65), p. 10 right and p. 11 left and right Emilia Stasiak/iStockphoto/Thinkstock.com, p. 15 right Tim Newman/iStockphoto/Thinkstock.com, p.29 right Robbi/Shutterstock.com, p. 54 bottom Inacio Pires/Shutterstock.com, p. 56 bottom Cameilia/Shutterstock.com, p. 58 bottom and p. 59 bottom Olga Miltsova/Shutterstock.com, all other images: Forschungszentrum Jülich. Excerpts from this issue may be reproduced without special permission provided that Forschungszentrum Jülich is referred to in any publication. A reference copy is requested. All other rights reserved.
As of: July 2011

Member of:

HELMHOLTZ GEMEINSCHAFT

www.fz-juelich.de