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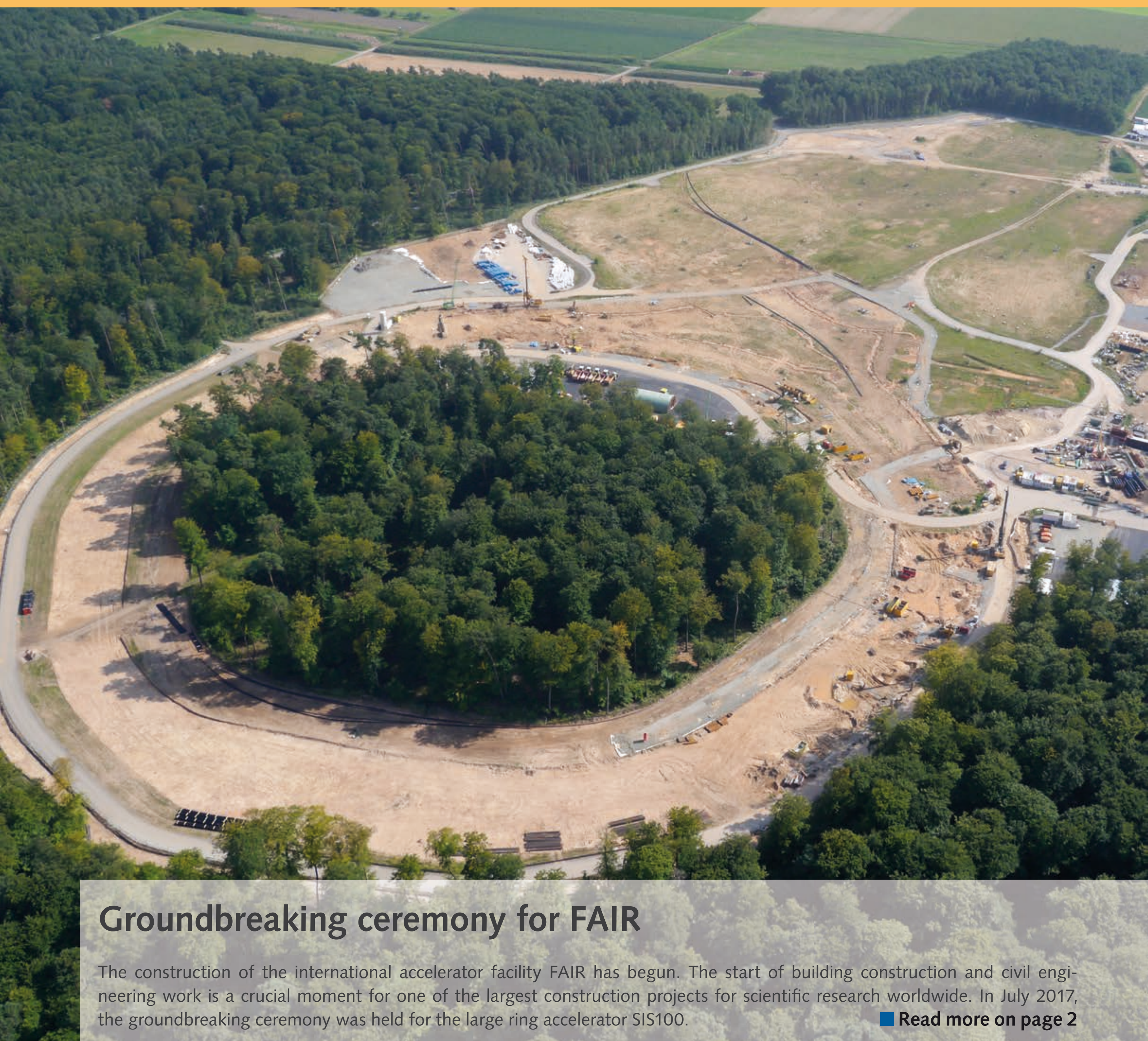

Groundbreaking ceremony for FAIR

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Dear reader,

We've experienced an overwhelming series of positive events in recent months. Our Open House Day was a big success, attracting 11,000 visitors. We were also able to hold the groundbreaking ceremony for the FAIR facility. Specifically, we began the civil engineering work for the construction of the large SIS100 ring accelerator. This marks the launch of one of the world's biggest scientific construction projects. We can see day by day how the work is progressing and how the construction site is continually changing in many ways.

At the same time, we are preparing new experiments for the existing facility. These will be conducted in 2018 and 2019. The start of the FAIR experimentation programme is known as FAIR Phase 0. Besides the newly developed FAIR detector components and the GSI accelerators that have been improved for FAIR, we can already use finished partial structures of FAIR, including the CRYRING storage ring. The big international demand and the high quality of the proposed experiments demonstrate the upcoming scientific programme's excellence and global appeal.

In addition to conducting research, we want to transfer possible applications resulting from the research to society and the economy. The Technology Transfer office explains how this can be done in the "Introducing GSI" section of this issue.

Pleasant reading!

Your FAIR and GSI Management Board
Paolo Giubellino
Ursula Weyrich
Jörg Blaurock

Groundbreaking ceremony for the FAIR accelerator facility

The construction of the international accelerator facility FAIR has begun. The start of building construction and civil engineering work is a crucial moment for one of the largest construction projects for scientific research worldwide. On July 4, 2017, the groundbreaking ceremony was held for the large ring accelerator SIS100, which will be the key component of the future accelerator facility FAIR. The construction site is located to the northeast of GSI.

FAIR will be a unique particle accelerator facility with an investment volume of more than €1 billion. The facility is being constructed by nine partner countries and is scheduled to go into full operation in 2025. Around 3,000 scientists from all over the world will work at FAIR, where they will gain groundbreaking insights into the structure of matter and the development of the universe. The key component of FAIR will be an underground ring accelerator with a circumference of 1,100 meters. Connected to it is a complex system of storage rings and experimental stations.

Over the past few weeks and months, extensive preparations have been made for the huge construction project. For example, work is already under way to connect the existing accelerator facilities of GSI to the new FAIR complex. Retaining walls are being built and contracts have been awarded for the excavation and installation of the ring tunnel following a successful call for bids. These were important preparatory steps for the large-scale work on the FAIR infrastructure, which has now begun with the groundbreaking ceremony for the SIS100 ring accelerator. The cutting-edge accelerator and experiment facilities will be installed after the new buildings are completed.

At the ceremony, government officials and scientists from Germany and abroad extended greetings and symbolically broke the ground with a shovel. This crucial milestone was attended by representatives from all nine partner countries. Georg Schütte, Chair of the FAIR Council and State Secretary at the Federal Ministry of Education and Research, said, "The beginning of the civil construction of FAIR marks a new phase in the project. FAIR is a highly complex large research project at the limits of scientific and technical feasibility. This project and its diverse challenges can only be managed in close alliance with our international partners. We expect FAIR to become a driver of innovation in many areas, ranging from fundamental research and application-oriented developments to technical building solutions."

Georg Schütte, Chair of the FAIR Council and State Secretary at the Federal Ministry of Education and Research gave a welcoming speech.

The Scientific Managing Director of FAIR and GSI, Professor Paolo Giubellino, emphasized the great potential that FAIR offers for scientific research: "FAIR will create unique opportunities for cutting-edge research, with enormous discovery potential. Scientists will be able to study the universe in the lab: FAIR will address fundamental problems such as the origin of heavy elements in the universe or the structure of neutron stars, but also applications from material sciences to medicine. Through the close cooperation with researchers from all over the world FAIR will not only expand our knowledge but also be a motor for technological innovation while developing the next generation of scientists and engineers."

The Technical Managing Director of FAIR and GSI, Jörg Blaurock, added, "FAIR is an unusual construction project from both a scientific and a technological point of view. It requires customized solutions and the interplay of a wide variety of different trades. That's why building construction, civil engineering, accelerator development and construction, and scientific experiments are closely coordinated with one another in our integrated overall plan. The complex construction project is divided into manageable packages. Today's groundbreaking ceremony is the reward for precise preparatory work and shows that this is the right strategy for FAIR."

Ursula Weyrich, the Administrative Managing Director of GSI and FAIR, said, "We worked hard on developing the focus and the framework of the FAIR project and created an overall structure that organically links GSI Helmholtzzentrum für Schwerionenforschung GmbH with FAIR GmbH. This rearrangement of the overall organizational structure is an important precondition for the further implementation of the FAIR project. That's why today is also a success for the entire workforce and the result of outstanding and fruitful cooperation."

Eric Seng, Deputy State Secretary at the Hessian Ministry for Higher Education, Research and the Arts said, "The FAIR project is the further development of a Hessian idea almost 50 years old: GSI was founded in 1969 by an initiative of Hessian universities. GSI and FAIR have a world-wide appeal. As the hosting federal state we will do everything in our power for the international scientific community to not only feel welcome but enable them to perform cutting-edge research."

The FAIR directorate consisting of Jörg Blaurock, Technical Managing Director (l.), Professor Paolo Giubellino, Scientific Managing Director (m.) and Ursula Weyrich, Administrative Managing Director.

In line with the groundbreaking ceremony, FAIR also began FAIR Phase 0 of its experimentation programme in order to harmonize research operations with the progress of construction. Beam times are already being scheduled for researchers at existing GSI facilities and at components for FAIR. To conduct this research, scientists are using the GSI accelerator facilities, which have been substantially enhanced for their later use as preaccelerators for FAIR and will have their technology further upgraded in the future. Moreover, parts of FAIR can already be used, including the CRYRING storage ring.

„The scientific community looks forward to the mega project FAIR entering a crucial phase with today's groundbreaking", said the Indian professor Sibaji Raha, the Chair of the Joint Scientific Council of FAIR and GSI. „Already now scientists all over the world work on the research programme and the technical implementation of this facility, which will be unique in the world. FAIR will be the international showcase for hadron and nuclear physics in the coming decades and offer outstanding research opportunities."

Groundbreaking ceremony — left to right: Paula Eerola (Finland), Catarina Sahlberg (Sweden), Albin Kralj (Slovenia), Fanny Farget (France), Pascal Debu (France), Beatrix Vierkorn-Rudolph (Germany), Viacheslav Pershukov (Russia), Georg Schütte (Germany), Rakesh Bhandari (India), Zbigniew Majka (Poland), Ionel Andrei (Romania), Eric Seng, Deputy State Secretary at the Hessian Ministry for Higher Education, Research and the Arts, Sibaji Raha, Chair Joint Scientific Council, Sebastian Schmidt, Member of the Board of Directors, Forschungszentrum Jülich, Ursula Weyrich, Paolo Giubellino, Jörg Blaurock.

Transformers delivered for FAIR

Three high-performance transformers that will be needed for the future particle accelerator facility FAIR were delivered to the FAIR construction site in Darmstadt. Together with a fourth transformer that was already on site, the approximately eight-meter-long devices will connect FAIR to the regional power grid.

The transformers were manufactured in Turkey and transported by ship from Izmir to Rotterdam. From there, they were carried by 30-meter-long low loaders to Darmstadt-Wixhausen. "Thanks to our foresighted planning, everything went well despite the long distances and the lengthy approval process for obtaining a special road transport permit," says transformer specialist Udo Zerb from e-netz Südhessen.

In the next step, the transformers will be installed into the North and South Transformer Stations, which are currently under construction. Each transformer will weigh 114 tons when it is in operation. "The transformers will convert the 110 kV high-voltage electricity that arrives at GSI and FAIR through underground high-voltage cables to 20 kV so that the current reaches the various consumers on our campus in line with their needs," says Karl-Heinz Trumm, Head of the Electric Power Systems department at FAIR and GSI. FAIR will need up to 90 megawatts of electricity for its powerful electromagnets, infrastructure, cooling purposes, and other needs. The South Transformer Station will ensure that FAIR is supplied with enough electricity to meet its normal needs. The North Transformer Station is being built to supply energy to the SIS18 and SIS100 ring accelerators, because the special mode of operation of the normally conducting and superconducting magnets puts extreme demands on the quality of the electricity supply system. The North Transformer Station is scheduled to go into operation in December 2017, while the South Transformer Station is expected to go on line in spring 2018. ■

Via rails the transformers are put into position. The transformers are moved with pulles and muscular strength.

Accelerator and detector specialists meet at FAIR and GSI

The third annual Matter and Technologies conference ("MT meeting") was held in February 2017 at GSI and FAIR. Around 180 scientists from all over Germany were attending the event. The Matter and Technologies programme was established by the Helmholtz Association in order to emphasize and enhance the key role that technological development plays for accelerators and detectors, and consolidate it in a specific programme. Large research infrastructures such as accelerators, radiation sources, and detectors enable scientists from the research field Matter to study fundamental scientific questions regarding the origin and composition of matter.

Participants of the meeting.

One of the programme's main aims is to network the Helmholtz centres with one another and with universities. This goal was also the focus of the meeting in Darmstadt, which included a workshop and featured opportunities for participation in topic-specific meetings and a poster session. The Matter and Technologies programme is divided into two sections: Accelerator Research and Development (ARD) and Detector Technologies and Systems (DTS). As an important effect, the developments often lead to spin-offs in other fields. In detector technologies this is the case for example in medicine or in satellite-based astrophysics.

During the annual meeting at Darmstadt the young scientists associated with the programme held the third MT Student Retreat in parallel with the meeting. This meeting enables doctoral candidates to get to know one another and discuss their ideas and possible solutions. More than 40 participants attended the retreat in order to get an impression of the diverse areas covered by the research work in the Matter and Technologies programme. ■

From left: Jörg Blaurock, Technical Managing Director of FAIR and GSI; Dr. Georg Schütte, State Secretary at the Federal Ministry of Education and Research and Chairman of the GSI Supervisory Board and FAIR Council; Ursula Weyrich, Administrative Managing Director of FAIR and GSI; Professor Dr. Paolo Giubellino, Scientific Managing Director of FAIR and GSI; Professor Dr. Otmar D. Wiestler, President of the Helmholtz Association.

JOINT MANAGEMENT COMPLETE

Professor Paolo Giubellino is new Scientific Managing Director of GSI and FAIR

At a ceremony held in March 2017, Professor Paolo Giubellino was inaugurated as the first joint Scientific Managing Director of GSI and FAIR. The festive inauguration ceremony was held at the Darmstadtium science and congress centre. The guests included numerous politicians, university representatives, and partners from the organizations' international scientific collaborations.

Greetings were delivered by Dr. Georg Schütte, State Secretary at the Federal Ministry of Education and Research and Chairman of the GSI Supervisory Board and FAIR Council, and Professor Otmar D. Wiestler, President of the Helmholtz Association. Words of greetings were also spoken by Dr. Rolf Bernhardt from the Hessen State Ministry for Higher Education, Research and the Arts, Jochen Partsch, Mayor of the City of Darmstadt, and Professor Angela Bracco, Chair of the Nuclear Physics European Collaboration Committee (NuPECC) — an expert committee of the European Science Foundation (ESF).

In his role as Scientific Managing Director, the 56-year-old Italian physicist Paolo Giubellino succeeds Professor Boris Sharkov at FAIR and Professor Karlheinz Langanke at GSI. By taking up his new position, he completes the joint management team of GSI and FAIR. This doubling up of managerial responsibility is also the case with the Administrative Managing Director Ursula Weyrich, who was appointed in late 2014, and the Technical Managing Director Jörg Blaurock, who was appointed in early 2016. The GSI Supervisory Board and the FAIR Council had announced their decision to appoint Paolo Giubellino in September 2016, and Giubellino took up his duties in January 2017.

Dr. Georg Schütte, State Secretary at the Federal Ministry of Education and Research and Chairman of the GSI Supervisory Board and FAIR Council, said, „Paolo Giubellino‘s appointment as Scientific Managing Director completes the joint management team of GSI and FAIR. It guarantees excellent future research at FAIR. The foundation for this is laid by GSI's current scientific work. I wish the three directors Paolo Giubellino, Ursula Weyrich and Jörg Blaurock much success with their challenging task to realize FAIR in the framework agreed upon with the international partners.“

In his ceremonial address, Paolo Giubellino offered a glimpse of the future and expressed his enthusiasm about his new workplace. "Its research potential is unique," he said. "An unprecedented variety of experiments will be possible at FAIR. Through them, physicists from all over the world can expect to gain new insights into the structure of matter and the evolution of the universe, from the big bang until today. The FAIR project guarantees future-oriented further development, not only for the centre in Darmstadt but also for fundamental research in all of Europe and beyond." The new Scientific Managing Director's vision of the future also includes up-and-coming young scientists. "Today we already need lots of bright young people — highly qualified young scientists who will contribute their talent and their know-how to the creation of FAIR," he said. Giubellino concluded with a promise: "I will do everything I can to help ensure that we can work together to fully exploit the tremendous research potential of GSI and FAIR." ■

OPEN HOUSE

Almost 11,000 visitors at GSI and FAIR

Visitors received an opportunity to be researchers and discoverers for a day in May 2017 at the Open House event of GSI and FAIR. Finally, GSI and FAIR took a positive stock of the event. Almost 11,000 visitors came to the campus in Darmstadt to view the research stations, laboratories, and experimental setups. GSI and FAIR had opened their doors to guests for eight hours, and thousands of curious visitors, including many families, took advantage of this well organized event to take a look behind the scenes of one of the leading particle accelerator centres for fundamental research in physics.

The visitors were treated to an extremely varied programme. At more than 30 stations and in the course of five different tours, they were able to conduct hands-on experiments and gain insights into the research using ion beams that is being done at the centre. Visitors of all ages were enthusiastic about the centre's world-leading research and the exciting scientific stations, which ranged from a stand demonstrating the ion-beam cancer therapy that was developed in Darmstadt to a 120-meter-long linear accelerator to the FAIR Forum with information about the new particle accelerator centre or the impressively staged large-scale detector HADES.

Big rush on the campus of GSI and FAIR.

The motto of the Open House was "The Universe in the Laboratory." The employees at GSI and FAIR had made special preparations to the research operation so that visitors could gain an understanding of as many topics as possible. More than 400 volunteers were on hand during the Open House. They made sure the guests had an interesting and informative day, tirelessly answered their questions, and helped the guests to explore the GSI complex. Also for the physical well-being was well taken care.

The members of the GSI and FAIR management team were exceptionally satisfied with the event. Ursula Weyrich, the Administrative Managing Director of GSI and FAIR, said, "We are excited about the visitor's overwhelming interest in our work. The day has shown that research consists not only of fascinating technology, but also lives on dedicated and inspired employees." Professor Paolo Giubellino, the Scientific Managing Director of GSI, added, "We succeeded in raising excitement and curiosity for science. We are glad that so many young people came. Science needs interested junior researchers and many clever minds employing their talents for research." Jörg Blaurock, the Technical Managing Director of GSI and FAIR, also judged the event to be a great success. "Our Open House highlights the fascination carried by research. We were able to demonstrate in a direct dialogue what our world-wide unique FAIR project encompasses, which guarantees a promising future trend for the location Darmstadt."

Unique insights and a lot of information was offered to the visitors all around the campus, e.g. at the HADES detector.

Jochen Partsch, the Mayor of Darmstadt, a "City of Science," also came to the Open House and officially opened the event together with the management team of GSI and FAIR. Partsch said, „I am extremly pleased that GSI has opened its doors to the citizens of Darmstadt in the anniversary year ‚20 years City of Science'. It was a unique opportunity to get to know cutting-edge research right in front of the doorstep. The fact that so many people have used this opportunity shows how deeply connected the inhabitants of Darmstadt are with the City of Science and how exciting it is for them to ‚explore' GSI on their own. We live in a city which is eponym of a chemical element discovered at GSI. Here, breakthroughs in cancer therapy have been achieved and with the FAIR project a new particle accelerator is currently being built which will set a new standard worldwide. Therefore, excellent research does not take place anywhere in the ivory tower but can rather be experienced by everyone thanks to an open house day. Furthermore, you should not forget that in addition to new knowledge, research also creates important jobs and shapes the life in our city." ■

Visitors from outer space, courtesy of the "501 German Garrison" costume club, whose members appeared in costumes from the Star Wars saga.

Many opportunities for experiments invited all ages to participate and try some physics.

Around 300 nuclear physicists meet in Darmstadt — GSI and FAIR accelerator centre play an outstanding role

Participants of the NuPECC meeting in Darmstadt.

Around 300 nuclear physicists from around the world met in Darmstadt at the beginning of the year for an international conference of the Nuclear Physics European Collaboration Committee (NuPECC) — an expert committee of the European Science Foundation (ESF). The three-day event — known as a Town Meeting — has been organized by GSI. The purpose of the conference is to set the long-term course and lay out the Long Range Plan for the future of European nuclear physics, thus marking a key milestone for the next decade.

The Long Range Plan regularly establishes the perspectives and prospects of the European nuclear physics community for the next ten years and beyond. Its contents are presented to the European and national bodies for science funding as planning suggestions. "The Long Range Plan provides the community with an opportunity to formulate how Europe should position itself in order to remain a world leader and competitive in an international context," explained Professor Angela Bracco, NuPECC Chair. "GSI and the future FAIR accelerator centre play an outstanding role in this effort." According to Bracco, the new possibilities for research in Darmstadt are unique and are expected to produce groundbreaking new insights for nuclear research.

Professor Paolo Giubellino, the Scientific Managing Director of GSI and FAIR, also reported on the FAIR project at the Town Meeting, emphasizing the outstanding role played by the Darmstadt location and FAIR/GSI in this area of science. "The FAIR project builds on the excellence of GSI and guarantees a promising future development with outstanding experimental facilities within European research."

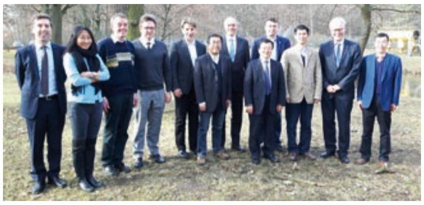
The members of NuPECC come from more than 20 European countries. They represent the European nuclear physics community and important research centres and funding agencies. The tasks of the renowned expert committee include providing the European Science Foundation and other bodies with suggestions and recommendations, and coordinating activities in the fields of nuclear and hadron physics within Europe. ■

FAIR and NICA: Test facility for superconducting accelerator magnets goes into operation in Russia

Festive ceremony in Dubna.

A facility for testing superconducting magnets for the two future accelerator centres FAIR and NICA (Nuclotron-based Ion Collider fAcility) in Dubna, Russia has been put into operation with a festive ceremony. NICA is being constructed in Dubna at the Joint Institute for Nuclear Research (JINR). The ceremony was attended by a delegation from FAIR. Together with the management of the NICA project, the delegation members put the new facility into operation. JINR and GSI shared the costs of building the facility. The new facility has three connections on each side for testing magnets at extremely low temperatures. The connections on one side are for the series of booster and collider magnets for NICA and those on the other are for the series of quadrupole units for the FAIR accelerator ring SIS100. German companies made a major contribution to the facility's construction. ■

Chinese delegation visits FAIR and GSI



Perspectives of future cooperations were primary focus during the Chinese Academy of Sciences (CAS) delegation's visit at FAIR and GSI. The scientific exchange was initiated already 40 years ago; by now the cooperations have developed successfully and intensified further on many research areas: from hadron physics to nuclear and atomic physics up to accelerator physics. ■

Thai princess visits GSI and FAIR

Representatives of GSI/FAIR and of Thai research institutions signed a memorandum of understanding in the presence of Her Royal Highness Maha Chakri Sirindhorn (5th from left).

A royal visitor from Thailand: Her Royal Highness Princess Maha Chakri Sirindhorn of Thailand visited GSI and FAIR in Darmstadt. During her tour, the princess learned about the latest research activities, the various infrastructures, and the future FAIR accelerator centre. A memorandum of understanding (MoU) was also signed during the visit in order to promote scientific and technological cooperation between the research institutes of the two countries.

The management of GSI and FAIR welcomed the princess along with the delegation from Thailand, which included representatives of the country's scientific and diplomatic communities. After listening to a presentation about GSI and FAIR, the visitors toured the GSI campus and the FAIR construction site. During the tour, the visitors made stops at the Green IT Cube, one of the most modern and efficient high-performance computer centres in the world, the HADES large-scale detector, and the facility for ion-based cancer treatments that have been developed at GSI. Princess Maha Chakri Sirindhorn and the Thai delegation then learned about the international FAIR project, one of the world's biggest construction projects for scientific research, and viewed the work that is currently being performed on the 20-hectare construction site next to the GSI campus.

The visit concluded with the signing of a memorandum of understanding concerning the establishment of a scientific and technological partnership between five Thai universities and scientific institutes on the one hand and GSI and FAIR on the other. Among other things, the MoU encompasses a variety of opportunities for collaboration and information-sharing such as seminars, symposiums, and science meetings. The memorandum will also promote cooperation by means of joint research projects and exchange activities between professors and scientists — particularly young scientists, postdocs, and university students.

Princess Maha Chakri Sirindhorn is working to promote humanitarian projects and improve education in the Kingdom of Thailand and around the world. She is widely known for her strong interest in science and technology. She has also won numerous awards in Thailand and abroad for her commitment to improving international relations. ■

40 years of cooperation with the Institute of Modern Physics in China

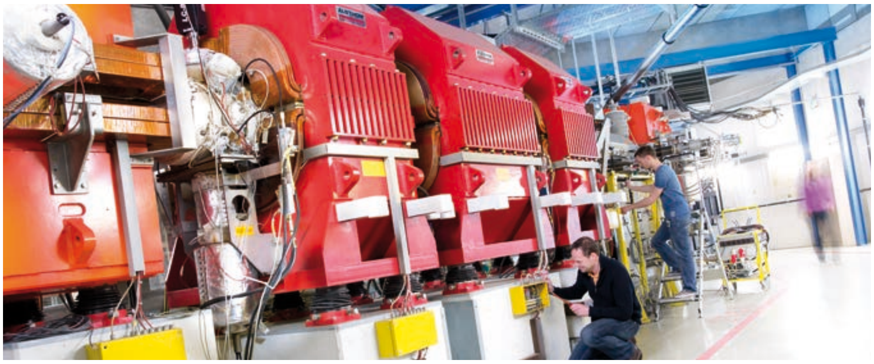
The collaboration between GSI and the Institute of Modern Physics (IMP) in Lanzhou, China, celebrates its 40th anniversary this year. On this occasion, a commemorative event was held in September 2017 in Beijing, China, followed by a workshop for storage ring physics and accelerator technologies. Speakers at the ceremonial act were the head of the IMP, Professor Guoqing Xiao, as well as the Scientific Managing Director of GSI and FAIR, Professor Paolo Giubellino.

The cooperation between GSI and Chinese research facilities can look back on a long tradition. The starting points were personal contacts between researchers of GSI and IMP in the 1970s. A regular exchange programme was established in the following years with stays of Chinese researchers at GSI and visits of GSI scientists to Lanzhou, which is still on-going. Scientific exchange and cooperation with China has since prospered into many areas ranging from hadron, nuclear and atomic physics to plasma research, radiation-biology, radiation safety, accelerator physics and vacuum technology.

The course for a continuation of this valuable collaboration has already been set. In spring 2017 the agreement of collaboration between IMP and GSI has been prolonged for another five years and also the FAIR GmbH has been added as a partner. ■

The head of IMP, Professor Guoqing Xiao, and the Scientific Managing Director of GSI and FAIR, Professor Paolo Giubellino, celebrated the long lasting collaboration in Beijing.

Funding for quantum dynamics research at GSI and FAIR



The experimental storage ring ESR at GSI.

FAIR, which is currently being built at GSI, will open up outstanding possibilities for experimentation. These opportunities are already attracting a great deal of interest from the scientific community. That's because the planned FAIR accelerator facility has a huge potential to provide us with new insights. This view is also shared by the German Research Foundation (DFG), which has now approved around €168,000 in German funding for a research project that combines the activities of two world-renowned research groups from Germany and Russia and focuses on the research that will be conducted at GSI and FAIR in the future. Russia will provide an equivalent amount in funding for the Russian group.

Among other things, the money will be used to provide two years of funding for a postdoc position for studying the theory and experiments at GSI and FAIR. This research will focus on the PHELIX high-energy laser system, the CRYRING storage ring (FAIR's first ion storage ring), and the ESR experimental storage ring. More specifically, the research will address the preconditions for investigating relativistic quantum dynamics in experiments at the GSI and FAIR research facilities. The DFG funding proposal was made in response to a joint German-Russian application submitted by Professor Thomas Stöhlker, Head of the Atomic Physics Division at GSI, Director of the Helmholtz Institute Jena, an outpost of GSI in Jena (HIJ), and holder of the Chair at the Friedrich Schiller University Jena, Institute for Optics and Quantum Electronics, and by Professor Vladimir Shabaev, Head of the Quantum Mechanics Division at St. Petersburg State University. Moreover, Dr. Angela Bräuning-Demian and Dr. Alexandre Gumberidze from the Atomic Physics Division of GSI are also extensively involved in the project.

Collisions of heavy ions play a key role in researching the relativistic quantum dynamics of electrons in very strong electromagnetic fields. The implementation of the FAIR project will open up new opportunities for investigating the collisions of super-heavy ions and atoms at low energies. Experimental investigations of such collisions are being planned at GSI and FAIR, and the associated theoretical studies are urgently needed. "This will be addressed by our research project, which is why it is coming at precisely the right time," state Stöhlker and Shabaev, who also emphasize how important this work will be for the understanding of additional experimental findings at GSI/FAIR.

Another important aspect is the collaboration between the two groups. While Russia covers the costs of the Russian group, Germany does the same for the German group. "It's a very effective way for promoting international cooperation between the groups," say Stöhlker and Shabaev. ■

International Masterclass 2017 at FAIR and GSI — On the hunt for particles

In March 2017 the 7th International Masterclass took place at FAIR and GSI. 14 high-school students were invited to become a scientist for a day and analyse data from the ALICE experiment at the LHC accelerator at CERN in Geneva. GSI has had a major part in the construction and the scientific programme of ALICE from the beginning.

The young persons were asked to evaluate and interpret data of the ALICE experiment. Under professional supervision of scientists they autonomously analysed recent data recorded in proton-proton and lead collisions. In the lead collisions a so-called quark-gluon plasma is generated — a state of matter which existed in the universe shortly after the big bang. This plasma undergoes a phase transition back to normal matter in fractions of seconds. The particles produced in the process can give insight into the properties of the quark-gluon plasma. ■

Particpants of the International Masterclass 2017 in front of a model of the ALICE detector.

Cooperation of CNAO and GSI

Therapy cave at CNAO.

The Italian National Center for Oncological Hadrontherapy "Centro Nazionale di Adroterapia Oncologica" (CNAO) and GSI signed a contract to improve the technology of cancer therapy with heavy ions. Within the collaboration the established CNAO control system will be installed and further developed in Darmstadt.

Ion beam therapy permits a more precise irradiation in comparison to conventional therapy with high doses to the tumour while sparing surrounding healthy tissue. CNAO in Italy is one of the facilities in Europe where this radiation modality is available for therapy; it uses the raster scan technology that has been developed at GSI. To enhance this technique the irradiation control system of CNAO will now be installed at GSI. "The control system developed at CNAO has the advantage of flexibility and easy maintenance because it is based on modern industrial components", explains Michael Scholz, head of the GSI Biophysics department. "This facilitates rapid implementation of the new developments planned at GSI."

The main goals of these improvements are to reduce the irradiation time and to integrate motion management techniques, allowing a more precise treatment of tumors that move with breathing. The transfer of these upgrades to the clinical environment for the benefit of patients is then largely facilitated thanks to the close collaboration with CNAO existing already for many years also in other areas like accelerator construction an beam diagnosis. ■

Schoolgirls find out about GSI and FAIR on Girls' Day

Participating girls create thin foils in the target laboratory.

On Girls' Day, 32 schoolgirls from grades 5 through 10 had the opportunity to find out what it's like to work at GSI and FAIR. They took advantage of this future-oriented day to gain an insight into the many activities that are pursued at an international research institution, especially in professions where women have seldom been represented so far.

For the participants, Girls' Day began with a welcoming address by Ursula Weyrich, the Administrative Managing Director of FAIR and GSI. This was followed by a tour of the particle accelerator and experiment facilities on the research campus, which made the girls curious and generated many questions: How big are atoms? Is it possible to see them? How is a detector put together?

After that, the girls could gain practical experience in various technical and scientific working areas at workshops, technical laboratories, and research departments. Many departments had prepared for the girls' visit by creating a special programme, and they provided plenty of support for their young visitors. For example, the girls were able to try their hand at milling, soldering, and programming. They were also given a tour of the construction site of the world-wide unique particle accelerator FAIR.

After all this, the girls could look back on an exciting day during which they had achieved many practical results. For example, they had milled pencil holders and buttons for themselves, created targets — the paper-thin foils that are used as samples for experiments, equipped a circuit board with LEDs and connected it, and created their own web page. One highlight of the day was the ice cream they made themselves by using liquid nitrogen.

Girls' Day is a day of action all over Germany. On this day, businesses, factories, and universities all over Germany open their doors to schoolgirls from grade 5 and above. There, the girls learn about courses of study and professions that offer traineeships in the areas of IT, the skilled trades, the natural sciences, and technology — areas where women have seldom been working in the past. ■

GET_INvolved Programme: Initiating bilateral cooperation between IIT Ropar, India, FAIR and GSI

FAIR and GSI recently received a delegation from the Indian Institute of Technology (IIT) Ropar. The delegation included scientists, faculty members and members of international affairs. The visit to FAIR and GSI began with a warm welcome by the NUSTAR collaboration followed by a roundtable meeting with Joint Scientific Managing Director Professor Paolo Giubellino and Joint Research Director Professor Karlheinz Langanke and several department heads of FAIR and GSI.

Delegation from IIT Ropar visiting the FAIR/GSI campus.

Professor Giubellino informed the delegation about the current and future research programme of FAIR and GSI along with opportunities for both parties to strengthen their collaboration with NUSTAR and also expand by participating in the GET_INvolved Programme. Professor Munjal on behalf of the IIT Ropar's delegation expressed the interest to participate in the active training of young students and researchers of the IIT Ropar and also in an exchange of scientific staff from both institutes to enhance the relationship. The delegation also had an active session with the heads of different research pillars. The delegation expressed their keen interest in formulating a Memorandum of Understanding for joint areas of cooperation and a dedicated agreement for a student training and an exchange programme of research staff.

IIT Ropar is an advanced technical institute located in the north-west of India in the state of Punjab (approximately 300 km north of New Delhi). IIT Ropar is already a member of NUSTAR with several researchers and students working actively on optimisation and development of a Gamma camera (a patented technology manufactured and developed at GSI). The institute is also involved in the testing of the components for the DEGAS detector (NUSTAR) at IIT Ropar. ■

Delegation from San Antonio visits GSI and FAIR

Current research and future developments at GSI and FAIR were main topics during the visit of a delegation from Darmstadt's new sister city San Antonio in Texas. The programme of the high-ranking delegation from the US-American metropolis, which is visiting Darmstadt to finalize signing of the sister city agreement, included after the greeting by Joint Research Director Professor Karlheinz Langanke, a visit to the research facilities on campus. The guests also had the opportunity to find out about the current status of the unique FAIR accelerator facility, which at present is being built at GSI.

The visitors from San Antonio participated in a guided tour of GSI and FAIR.

Among the members of the delegation visiting GSI and FAIR were representatives of the political committees of the city of San Antonio, its scientific institutions and the Chamber of Commerce as well as representatives of the city of Darmstadt. Hightech, research and development were among the leading themes of the programme for the American guests during their stay in Darmstadt. ■

INTERVIEW

Alexander Bayer, 18, lives in Aalen and is in the 11th grade. As a result of his participation in the "Jugend forscht" science competition, he was granted a two-week internship in the Ring HF department at FAIR and GSI.

Mr. Bayer, what was your project in the "Jugend forscht" competition?

My friend Niklas Gutsmiedl and I built a robot that can replace a guide dog. The robot knows how to move around obstacles, operate in road traffic, and recognize traffic lights and pedestrian crossings, for example. The robot has a handle a blind person can use to steer it like a dog. The robot sends out acoustic signals or vibrations in the handle in order to guide the user and warn him or her about obstacles ahead. We had two people at my school who were visually impaired. That made us aware of this problem. Guide dogs are expensive and often hard to come by. So we thought it must be possible to create an electronic alternative to such dogs.

Exactly how does the robot work?

We mounted it on a basketball. Motors are attached to the ball to provide motion. The robot looks a bit like BB-8, the small spherical droid from the most recent Star Wars movie. Because the robot runs on a single ball, it can overcome minor obstacles such as doorsteps. That would be difficult if the robot had wheels. At the top of the robot is a 3D camera. We simply used a Kinect system from the Xbox. The data is processed by a Raspberry Pi computer. To provide the robot with software, for example for image processing, we sometimes bought finished packages, but we also did a lot of programming ourselves. The use of such standard components makes the system relatively inexpensive.

How have visually impaired people reacted to the robot?

We've had several visually impaired people test the system. They gave us good tips on how to make the robot even better. For example, it's possible to augment it with a Bluetooth headset that allows blind people to communicate with the device more effectively. However, the people who tested it were very satisfied overall. That's why we now have a patent pending and are currently looking for investors. We also want to get in touch with health insurance companies soon to find out whether they would be willing to bear the costs.

What are you currently doing during your internship at GSI and FAIR?

I'm working at the Ring HF department, which provides the high frequency that is needed for the ring accelerators. I've been able to look at parts of the facility, such as the CRYRING storage ring. It was impressive to see an accelerator up close. One of my tasks during the internship is to build a theremin, an electronic musical instrument. I've already completed the housing and wound the coils. I'm now soldering together a few circuit boards.

You are working eight hours a day during your internship. Is that more strenuous than going to school?

It isn't more strenuous — just different. The work here is much more practical. It's diverse and it's fun. I've already learned plenty of new things, such as how carefully you have to wind coils. At school you spend most of the day sitting and listening to what the teacher says. But our school also has several interesting things to offer, including new rooms for the natural sciences and even a 3D printer. We used it to make parts of the robot.

What do you like to do during your leisure time?

Here in Darmstadt, I've gone swimming and jogging a few times. But my main hobbies are physics, electrical engineering, and electronics. I spend a lot of time on these subjects at home as well. Of course I'm also working on enhancing the robot. I definitely want to have a job in this field one day. At the moment, I think it would be best if I studied electrical engineering.

Alexander Bayer, here working at the FAIR storage ring CRYRING, knows a lot about electronics.

Visualization of a neutron star merger.

PREDICTIONS CONFIRMED

Heavy elements in neutron star mergers detected

Central predictions by GSI scientists on the formation of heavy elements such as gold and platinum in the universe have now been observed astrophysically. For the first time gravitational waves of merging neutron stars were detected. This also puts further focus on the future accelerator facility FAIR, as conditions for further research on neutron stars can be simulated there.

On October 16 a team of scientists, including members from the LIGO and Virgo collaborations and several astronomical groups, announced the detection of both gravitational and electromagnetic waves, originating from the merger of two neutron stars. These mergers have been speculated as the yet unknown production site of heavy elements including gold, platinum and uranium in the Universe. In 2010 an international collaboration led by Gabriel Martínez-Pinedo (GSI and Technische Universität Darmstadt) and Brian Metzger (Columbia University) pointed out that the heavy element synthesis in the merger process leads to a unique electromagnetic wave emission pattern.

The electromagnetic signal observed from the merging neutron stars indeed shows this pattern and confirms that the site for the heavy element production in the universe is finally found, solving one of the 11 most important question in physics, as named by the US National Academies in 2003. This breakthrough puts even further focus on FAIR, which is currently being built in Darmstadt and at which the short-lived and very neutron-rich nuclei which drive the observed electromagnetic signal will be produced and studied for the first time.

60 years ago the main processes responsible for the production of elements in the Cosmos were outlined. Since then, it has been possible to identify the astrophysical sites for most of those processes except for the so called r-process that is responsible for producing half of the elements heavier than iron. It requires an environment with extreme neutron densities, permitting neutron captures on nuclei to proceed much faster than beta-decays. „Identifying the site of the astrophysical origin of elements heavier than iron is viewed as one of the Millenium problems in physics“ says Friedrich-Karl Thielemann, professor at the University of Basel and now also member of the GSI theory group, who in 1999 performed the first nucleosynthesis study showing that the r-process can operate in material ejected during the coalescence of two merging neutron stars.

Almost simultaneously, it was suggested that the radioactive decay of the freshly synthesized nuclei will trigger an electromagnetic transient. The first realistic modeling of the electromagnetic signal was performed in 2010 by an international team led by Gabriel Martínez-Pinedo and Brian Metzger, including Almudena Arcones (GSI and Technische Universität Darmstadt) and key experimental guidance from GSI scientists Aleksandra Kelic-Heil and Karl-Heinz Schmidt. They predicted that such an event will be a thousand times brighter than a nova and will reach its maximum on timescales of a day. It was named „kilonova“. This picture has been confirmed by the recent observation of an optical/infrared counterpart associated with GW170817. „This represents a unique case in nuclear astrophysics, as usually astronomers observe a new phenomenon which is much later explained by theorists. In the present case we anticipated a novel astronomical signal without the benefit of observational guidance much before it was confirmed by observations“, says Gabriel Martínez-Pinedo.

Several signatures point to the radioactive decay of r-process nuclei to explain the observations. The time dependence of the signal corresponds to what is expected assuming that the energy is produced from the decay of a large ensemble of radioactive nuclei. Furthermore, the evolution in color of the signal shows that a broad range of r-process nuclei has been produced from the lighter elements with $Z \sim 50$ to the heavier with $Z \sim 82$. It has been estimated that GW170817 produced around 0.06 solar masses of r-process ejecta with over ten times Earth's mass in gold and uranium. The LIGO and Virgo collaborations predict that once the gravitational wave detectors reach the design sensitivity in 2019 we may be able to detect neutron star mergers as frequently as once per week. This will represent a complete change of paradigm in our understanding of heavy element nucleosynthesis demanding high-precision nuclear data, in particular of heavy neutron-rich nuclei to reproduce the observations.

It is very fortunate that with FAIR the facility needed to provide these data is already under construction in Darmstadt. First results are expected from experiments performed in the FAIR Phase-0 starting 2018. Once FAIR reaches its complete potential in 2025, it will offer unique physics opportunities to determine the properties of heavy neutron-rich nuclei of relevance to r-process nucleosynthesis. In the meantime, it is the aim of the GSI theory group to identify key nuclear information to fully characterize the variety of electromagnetic transients expected from neutron star mergers. ■

Arrival of the first main magnet for the new large FAIR ring accelerator: Start of series delivery of 110 magnets

Important step: Start of series delivery of 110 magnets for the FAIR ring accelerator SIS100.

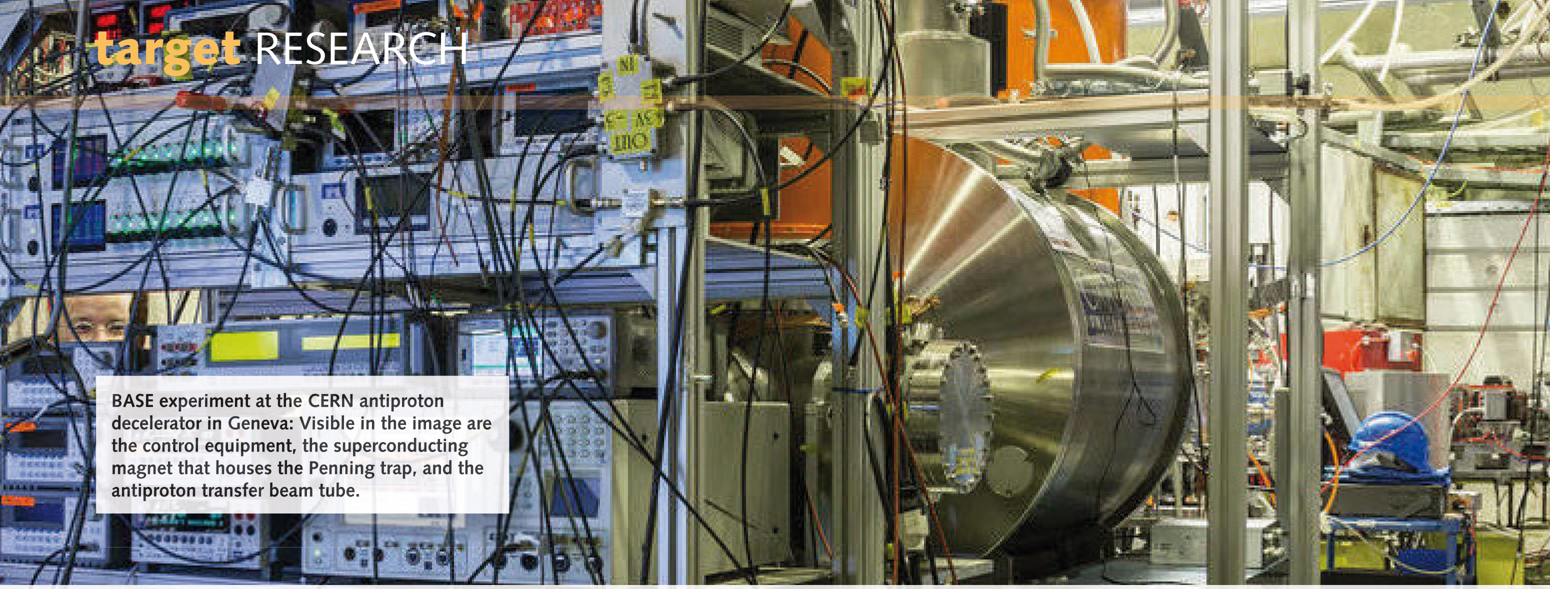
Big progress is being made in the production of the components of the new FAIR particle accelerator facility at GSI. At the heart of the future facility will be the 1.1-kilometer ring accelerator SIS100, which is very challenging from a technological point of view. An important step has now been taken in the accelerator's creation. It consists of the delivery of the first series-production main magnet for the new heavy-ion ring accelerator. The manufacture of magnets weighing several tons requires high-precision mechanical processing and analysis methods.

Special electromagnets and a special vacuum chamber are used to generate the magnetic field that forces the beams along a circular path. Both of these components are being produced by German manufacturers. The dipole magnets are being made by the company Babcock Noell (BNG) in Würzburg, while the vacuum chamber is being produced at the company PINK in nearby Wertheim. During operation, the dipole magnets are cooled to a temperature of minus 270 degrees Celsius in order to make the associated magnet coil superconducting. Superconductors enable electricity to flow through them without any resistance. This allows the magnets to be made very compact and limits the amount of electrical pulse power that is needed for the accelerator facility.

Moreover, the cold magnets will enable the integration of a similarly cold vacuum chamber through which accelerated ion beams will travel. To accelerate intense beams of heavy ions, the interior of the beam pipe needs to have vacuum conditions that are very close to those found in outer space. The vacuum chamber acts like a superpump on whose walls the gas particles that are not eliminated by conventional vacuum pumps freeze.

The magnets are technologically challenging not only with regard to their superconductivity, but also with respect to the level of mechanical precision that has to be achieved in the interior. To achieve optimal results, each of the two magnetic poles have to be positioned parallel to one another with a precision of ±50 micrometers.

BNG, which was awarded the contract for manufacturing the 110 dipole magnets that are required for the heavy-ion synchrotron SIS100, was able to demonstrate that it has the production technology needed to do the job with the first of series (FOS) magnet. The FOS dipole magnet achieved all of the specified properties during testing at GSI. After the acceptance tests were completed, GSI approved the magnets' series production. BNG has equipped a new assembly hall specifically for this purpose. ■



BASE experiment at the CERN antiproton decelerator in Geneva: Visible in the image are the control equipment, the superconducting magnet that houses the Penning trap, and the antiproton transfer beam tube.

RIDDLE OF MATTER

Proton and antiproton share fundamental properties

The search goes on. No differences in protons and antiprotons have yet been found which would help to potentially explain the existence of matter in our universe. However, physicists in the BASE collaboration at the CERN research centre have been able to measure the magnetic force of antiprotons with almost unbelievable precision. Nevertheless, the data do not provide any information about how matter formed in the early universe as particles and antiparticles would have had to completely destroy one another. The most recent BASE measurements revealed instead a large overlap between protons and antiprotons, thus confirming the Standard Model of particle physics. Around the world, scientists are using a variety of methods to find some difference. The matter-antimatter imbalance in the universe is one of the hot topics of modern physics.

The researcher of BASE compare the magnetic properties of protons and antiprotons with great precision. In the current study they took a look at the magnetic moment. Therefore they measure the so-called *g*-factor, which indicates the strength of the magnetic field. „At its core, the question is whether the antiproton has the same magnetism as a proton," explained Stefan Ulmer, spokesperson of the BASE group. „This is the riddle we need to solve."

The BASE collaboration published high-precision measurements of the antiproton *g*-factor early this year, but the current ones are far more precise. The current high-precision measurement determined the *g*-factor down to nine significant digits. The value of 2.7928473441(42) is 350 times more precise than the previous results.

Antiprotons are artificially generated at CERN and researchers store them in a reservoir trap for experiments. The antiprotons for the current experiment were isolated in 2015 and measured between August and December 2016, which is a small sensation as this was the longest storage period for antimatter ever documented. Antiprotons are usually quickly annihilated when they come into contact with matter, such as in air. Storage was demonstrated for 405 days in a vacuum, which contains ten times fewer particles than interstellar space.

The employed new measurement principle uses the interaction of two Penning traps. The traps use electrical and magnetic fields to capture the antiprotons. Previous measurements were severely limited by an ultra-strong magnetic inhomogeneity in the Penning trap. In order to overcome this barrier, the scientists added a second trap with a highly homogeneous magnetic field. The larmor frequency and the cyclotron frequency were measured; taken together they form the g-factor.

The g-factor ascertained for the antiproton was then compared to the g-factor for the proton, which BASE researchers had measured with the greatest prior precision already in 2014. In the end, however, they could not find any difference between the two. This consistency is a confirmation of the CPT symmetry, which states that the universe is composed of a fundamental symmetry between particles and antiparticles. „All of our observations find a complete symmetry between matter and antimatter, which is why the universe should not actually exist," explained Christian Smorra, first author of the study. „An asymmetry must exist here somewhere but we simply do not understand where the difference is. What is the source of the symmetry break?"

The BASE scientists now want to use even higher precision measurements of the proton and antiproton properties to find an answer to this question. The BASE collaboration plans to develop further innovative methods over the next few year and improve on the current results. The multinational BASE collaboration brings together scientists from CERN, the RIKEN research centre in Japan, the Max Planck Institute for Nuclear Physics in Heidelberg, the Johannes Gutenberg University Mainz (JGU), the University of Tokyo, GSI in Darmstadt, Leibniz Universität Hannover, and the German National Metrology Institute (PTB) in Braunschweig. ■

Ion treatments for cardiac arrhythmia

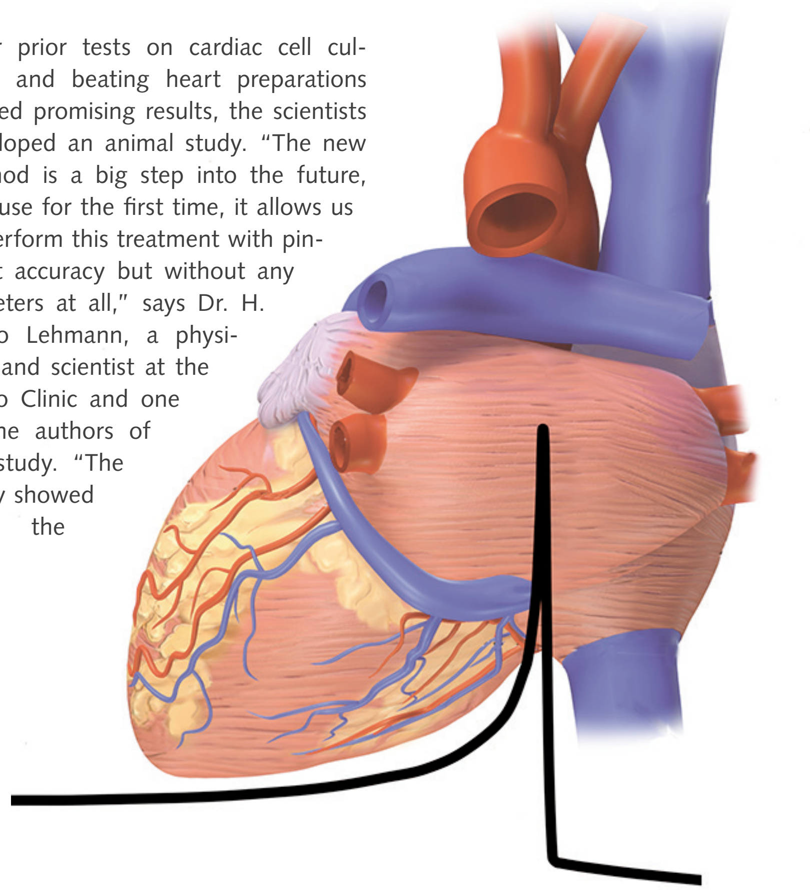
Accelerated particles as a non-invasive alternative to catheter-based surgery

At GSI was developed and tested a new method for a future treatment of cardiac arrhythmia. The research was carried by a team of biophysicists from GSI and physicians from Heidelberg University and the Mayo Clinic in the United States. Beams of carbon ions are already used successfully to treat tumors and could represent a non-invasive alternative to the present treatment with cardiac catheters or drugs.

Approximately 350,000 patients in Germany suffer from various forms of cardiac arrhythmia. The condition can lead to permanent damage as a result of stroke, or it may cause sudden heart failure. In forms of arrhythmia like atrial fibrillation or ventricular tachycardia, the heart departs from the regular rhythm set by a natural pacemaker, the sinoatrial node. This type of arrhythmia is often treated with drugs or with a "catheter ablation," in which catheters are guided through blood vessels to the heart, and certain tissue there is selectively destroyed. Based on this principle, ions from the particle accelerator could one day be used to perform a treatment without catheters. Scientists have been able to show that high-energy carbon ions can be used in a non-invasive procedure to make specific changes to cardiac tissue that prevent the transmission of the electrical signal.

This procedure using carbon ions has now been studied for the first time in a feasibility study by scientists at GSI in collaboration with physicians and scientists of the Mayo Clinic (Minnesota, U.S.), the Helmholtzzentrum Dresden-Rossendorf, the Heidelberg University, the Friedrich Alexander University Erlangen-Nuremberg (FAU), the Heidelberg Ion-Beam Therapy Center and the University of Trento (Italy). The researchers have published their results in the journal Scientific Reports from the publishers of Nature.

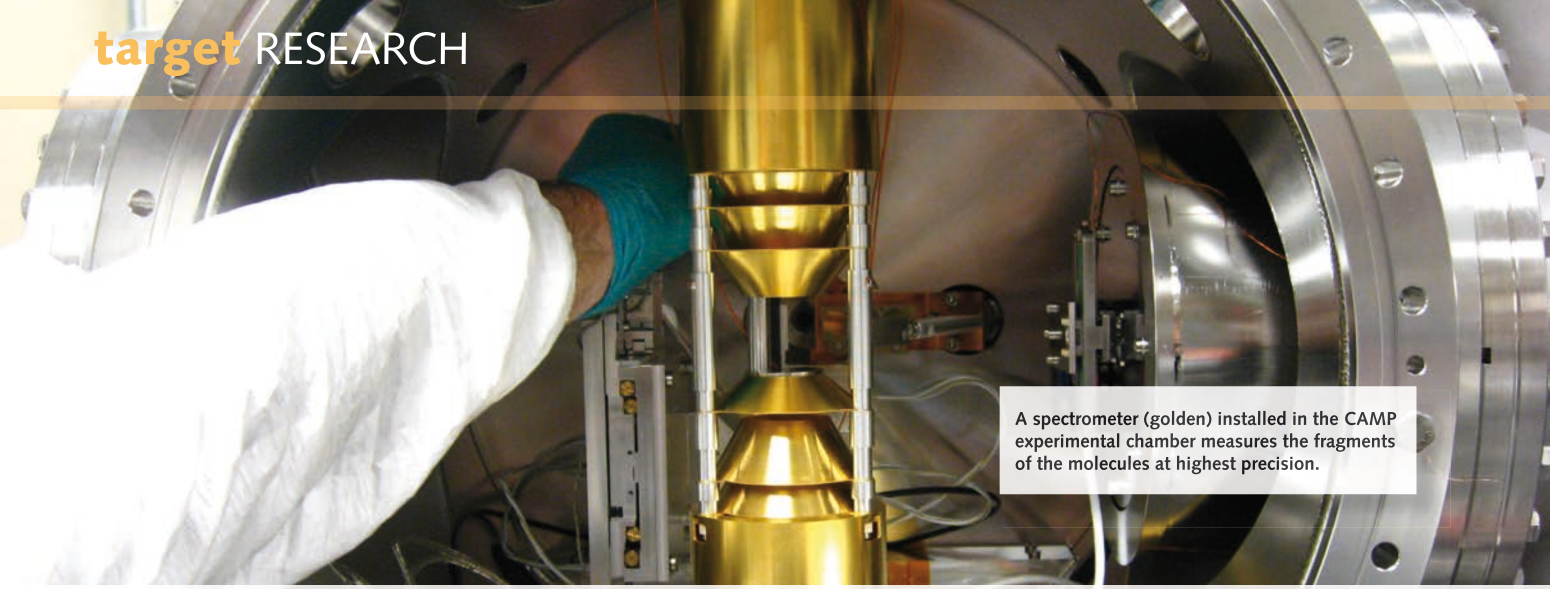
After prior tests on cardiac cell cultures and beating heart preparations yielded promising results, the scientists developed an animal study. "The new method is a big step into the future, because for the first time, it allows us to perform this treatment with pinpoint accuracy but without any catheters at all," says Dr. H. Immo Lehmann, a physician and scientist at the Mayo Clinic and one of the authors of the study. "The study showed that the method can be successfully used to change cardiac tissue in such a way as to permanently interrupt the propagation of disruptive impulses. Further detailed studies are needed, however, before the method can start to benefit patients," says Dr. Christian Graeff, head of the Medical Physics research group at GSI.



The treatment of cardiac arrhythmia with ions is studied at GSI. To do so, certain areas of the cardiac tissue are irradiated. In the area of the Bragg peak (black) ions deposit their energy and the tissue is destroyed.

The irradiation of tissue with carbon ions promises to be gentler and potentially also more effective than treatment with catheters. When the method is technically mature, the procedure will take only a few minutes, in contrast to the sometimes hours-long catheter operations. One crucial advantage is that the ions can penetrate to any desired depth. By contrast, since the left ventricular wall of the heart is especially thick, it is often not possible to effectively destroy tissue there with catheters, although this is precisely the spot at which patients suffering from severe forms of ventricular tachycardia must be treated.

In their study, the scientists were able to rely on many technologies originally developed for cancer treatment with scanned ions, which was carried out at GSI for the first time in 1997. This form of treatment has now become well established and has been used in thousands of patients worldwide. Further experiments are currently being planned so that the method can be put into practice at facilities such as the Heidelberg Ion-Beam Therapy Center. ■



A spectrometer (golden) installed in the CAMP experimental chamber measures the fragments of the molecules at highest precision.

WATCHING REACTIONS

Helmholtz cooperation lays foundations for the detailed observation of chemical processes using a tabletop laser and special-purpose detector

A team of researchers from the Helmholtz Institute Jena, a university branch of GSI, and DESY has paved the way for using novel laser systems to observe the dynamic process of chemical bonds being broken apart. For their experiments, the scientists combined high-performance light generation and detection components from the two Helmholtz institutions. The resulting setup forms the basis for observing high-speed processes with a resolution of 30 billionths of a second (30 femtoseconds). In addition, the setup is so compact and robust that it could serve as a prototype for measuring equipment that could be installed and operated even at smaller facilities and universities.

What happens when a chemical bond is broken? How do individual atoms join to form a molecule, and disengage from each other again? Understanding the dynamics of chemical processes is often described as the "Holy Grail" of physical chemistry; once you understand what is happening, you are in a position to influence such bonds and perhaps even design completely new materials.

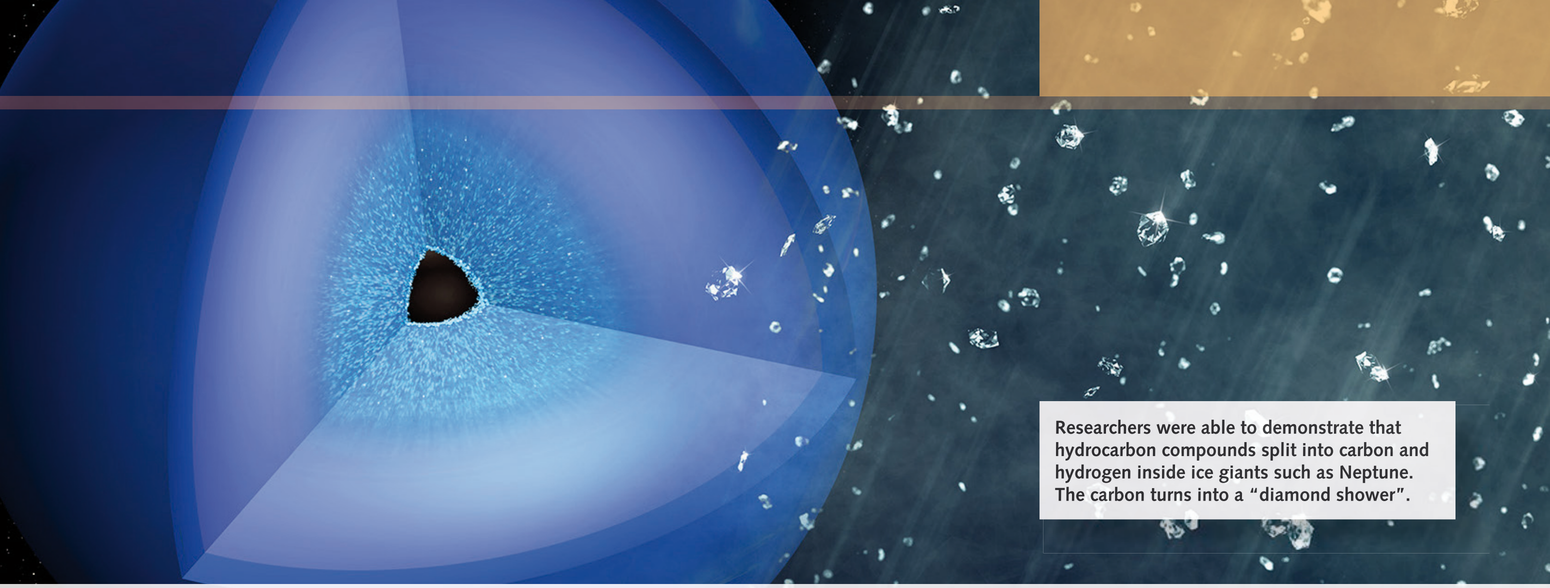
Observing such chemical processes with great precision calls for high-speed cameras with an extremely high temporal and spatial resolution, such as the X-ray free electron laser European XFEL, which was inaugurated in the Hamburg metropolitan region not long ago and will allow scientists to look at individual molecules and atoms. However, a laser that emits short-wave ultraviolet light is all that is needed to observe chemical bonds being broken in small molecules — that and a coincidence detector of the type developed for synchrotron and X-ray laser experiments.

In their experiments, the Helmholtz scientists fired short pulses of high-intensity XUV light at iodomethane molecules (CH_3I), also called methyl iodide, consisting of an iodine atom and a methyl group (CH_3). The light broke the bond between the iodine and the methyl group, and the fragments of the molecule were captured and measured in a spectrometer. This allowed the rearrangement of the electrons in the excited molecule to be deduced, and hence the subsequent induced chemical processes.

The experiments were based on a tabletop laser system for light in the so-called extreme ultraviolet range (XUV). The laser, which was developed at the Helmholtz Institute Jena, produces very short, high-intensity pulses of XUV by first strongly amplifying a pulse of infrared radiation in an optical fibre, and subsequently generating odd multiples of the original laser frequency. For these experiments, one of these so-called higher harmonic frequencies, with a wavelength of about 18 nanometres, was extracted using special optical devices and used for the experiment.

"The XUV laser system produces flashes of light consisting of one million photons, which only last 30 femtoseconds, with a pulse frequency of up to 100 kilohertz," explains Professor Jens Limpert. Jan Rothhardt, who helped to develop the laser, adds: "The combination of a high photon flux and very high repetition rate in combination with very high stability qualifies this system, in principle, to carry out user experiments in chemical dynamics."

"By bringing together the experimental and scientific possibilities from Jena and Hamburg, we are opening up new opportunities for observing chemical dynamics," says DESY scientist Professor Jochen Küpper, who instigated the experiments and who is also a member of the Center for Free-Electron Laser Science and the Hamburg Centre for Ultrafast Imaging at the University of Hamburg. DESY scientist Tim Laarmann adds: "In the next step, we will use the apparatus to conduct pump and probe experiments. In principle, this setup should in fact allow us to achieve much higher temporal resolutions of less than one femtosecond, making it possible to observe extremely fast movements of electrons in complex molecules." ■



Researchers were able to demonstrate that hydrocarbon compounds split into carbon and hydrogen inside ice giants such as Neptune. The carbon turns into a “diamond shower”.

DIAMOND SHOWER ON NEPTUNE

Team of researchers with GSI participation uncovers the inner workings of cosmic ice giants

In cooperation with colleagues from Germany and the United States, researchers at the Helmholtz-Zentrum Dresden-Rossendorf (HZDR) have managed to demonstrate ‘diamond showers’ forming in the ice giants of our solar system. Using the ultra-strong X-ray laser and other facilities at the Stanford Linear Accelerator Center (SLAC) in California, they simulated the conditions inside the cosmic giants. For the first time ever, they were able to observe the fission of hydrocarbon and the conversion of carbon into diamonds in real time. One GSI scientist participated in the experiments. The results were published in the journal “Nature Astronomy”.

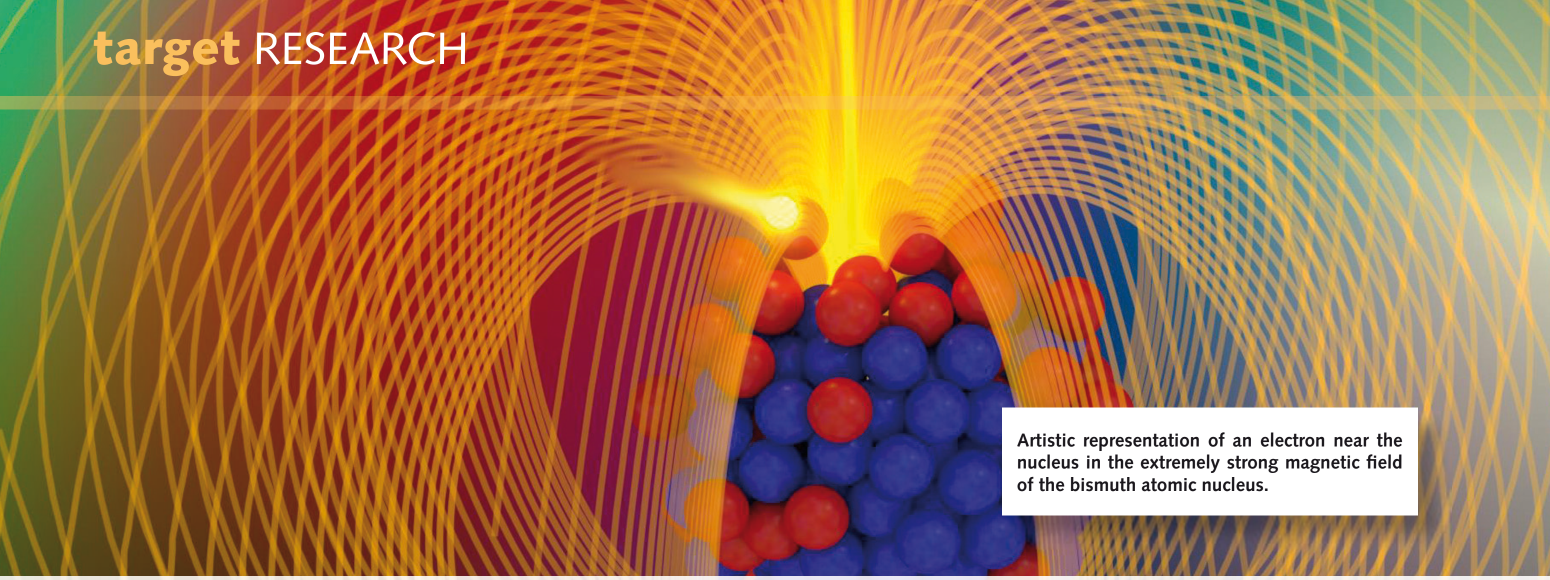
The interior of planets like Neptune or Uranus consists of a solid core swathed in thick layers of “ice”, which is mostly made up of hydrocarbons, water and ammonia. For a long time, astrophysicists have been speculating that the extreme pressure that reigns more than 10,000 kilometers beneath the surface of these planets splits the hydrocarbons causing diamonds to form, which then sink deeper into the planet’s interior. “So far, no one has been able to directly observe these sparkling showers in an experimental setting,” says Dr. Dominik Kraus, who is the head of a Helmholtz Young Investigator Group at HZDR. That was precisely the breakthrough Kraus and his international team have now achieved: “In our experiment, we exposed a special kind of plastic — polystyrene, which also consists of a mix of carbon and hydrogen — to conditions similar to those inside Neptune or Uranus.”

They did this by driving two shock waves through the samples, triggered by an extremely powerful optical laser in combination with the X-ray source Linac Coherent Light Source (LCLS) at SLAC. At a pressure of about 150 gigapascal and temperatures of about 5,000 degrees Celsius, they compressed the plastic. “The first smaller, slower wave is overtaken by another stronger second wave,” Dominik Kraus explains. “Most diamonds form the moment both waves overlap.” And since this process takes only a fraction of a second, the researchers used ultrafast X-ray diffraction to take snapshots of the diamonds’ creation and the chemical processes involved. “Our experiments show that nearly all the carbon atoms compact into nanometer-sized diamonds,” the Dresden researcher summarizes.

Based on these results, the authors of the study assume that the diamonds on Neptune and Uranus are much larger structures and likely sink down to the planet core over a period of thousands of years. “Our experiments are also providing us with better insights into the structure of exoplanets,” Kraus anticipates. Researchers can measure two main metrics in these cosmic giants outside of our solar system: The first one is mass, based on positional changes of the mother star; and the other is its radius, derived from the shadow that is cast as the planet passes a star. The relation between these two metrics offers clues about the planet’s chemical make-up, for instance, whether it consists of light or heavy elements.

“And, for their part, these chemical processes inside the planet tell us something about its vital properties,” Dominik Kraus continues. “This allows us to improve planetary models. As our studies show, previous simulations have not been accurate.” In addition to astrophysical insights, these experiments also hold potential for practical application. The nano-diamonds created in the experiments can be used in electronic instruments, medical procedures, or as cutting materials in industrial production. Current production of such diamonds is mainly done by blasting. Laser-based production could mean a cleaner and more controllable process.

The researchers from HZDR and SLAC were joined by scientists from the University of California in Berkeley, the Lawrence Livermore National Laboratory, the Lawrence Berkeley National Laboratory, GSI, the Osaka University, the TU Darmstadt, the European XFEL, the University of Michigan and the University of Warwick. ■



Artistic representation of an electron near the nucleus in the extremely strong magnetic field of the bismuth atomic nucleus.

ENERGY LEVELS

Interaction between the atomic nucleus and the electron on trial

For the first time, a team of researchers under the leadership of Technische Universität (TU) Darmstadt and with the participation of scientists from GSI has succeeded in measuring the transition between energy levels of the lithium-like ions of bismuth with such precision that it has become possible to reassess underlying theories. This has led to a surprising result. The scientists have now published this result in Nature Communications: the understanding of the interaction between an electron and an atomic nucleus that we have had until now might be erroneous.

At the surface of the nuclei of bismuth atoms, magnetic fields exist which are otherwise only present at the surface of massive neutron stars. The behavior of electrons in these fields has been investigated by a group of researchers under the leadership of the TU Darmstadt. Only recently have they achieved a breakthrough by observing for the first time a special transition in lithium-like ions of this element.

They have now succeeded in measuring this transition at GSI with such precision that it was possible for the first time to reassess the underlying theory convincingly. In the specialist journal "Nature Communications", the scientists give an account of their surprising result: the discrepancy between the theory and the experiment is striking. It suggests an error in our understanding of how an electron interacts with the complex inner structure of a nucleus.

Simple atoms consisting of a single nucleus and one or a few electrons are ideal systems to check our understanding of the underlying physical forces at stake. We have a better grasp of the theory of the atom's electron shell based on quantum electrodynamics (QED) than of the actual structure of the atomic nucleus. QED allows the properties of the electrons and the states in which the atom can exist to be calculated with great accuracy. These calculations are then checked by means of precision measurements. To date, QED has passed all these tests with flying colors.

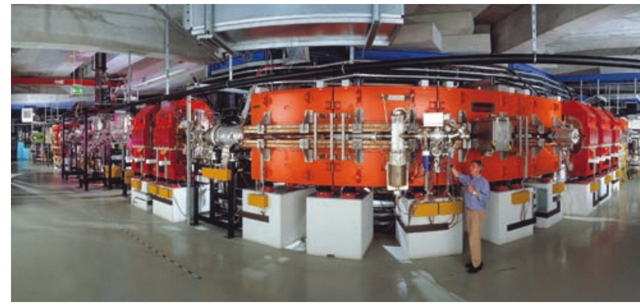
When using heavy nuclei, the scientists are mainly interested in the influence of the gigantic electric and magnetic fields on the electrons bound in the shell. Only very few experimental verifications of this theory have been carried out under these extreme conditions, and they do not — by far — exhibit the same accuracy as the experiments performed with light nuclei. The strong fields make the theoretical calculations much more difficult. In addition, the complex inner structure of the nuclei is not know with sufficient precision although it has a strong influence on the atomic shell.

In order to bypass this difficulty, theoreticians calculate certain differences for systems with different numbers of electrons, but with the same atomic nucleus. These so-called "specific differences" are of such a nature that the contributions of the nuclear structure should eliminate themselves almost exactly and that they can be used by the researchers as a starting point to check the QED calculations with more precision. The results that have now been published, however, seem to question the concept of specific difference.

In its experiment, the team first generated hydrogen-like and lithium-like bismuth ions. These ions were injected into the experimental storage ring (ESR) at the GSI accelerator facility which has a circumference of 108 metres and is equipped with two straight sections where experiments can be carried out. In one of those sections, an electron beam of defined energy is superimposed with the ion beam. After a few seconds, the ions' speed adjusts to that of the electrons. In this section, a pulsed laser beam is, in addition, superimposed with the ion beam. The laser's wavelength is then modified in tiny increments. When the laser reaches exactly the wavelength of the transition of the ion to be investigated, the ions absorb light particles (photons) — and thus energy — from the laser beam. Ions that are excited in this way release this energy after a short while, thereby emitting a very small number of photons.

This small number of photons was efficiently detected by means of a special mirror and a single-photon detection system which was developed at the University of Münster. Due to the high speed, the wavelength of the laser is compressed or stretched by a factor of approx. 2.4, for a counterpropagating or a copropagating laser, respectively. This factor depends on the accelerating voltage of the electrons. To measure this high voltage of approximately 214,000 volts with an accuracy on the order of one volt, a high-voltage divider developed at PTB in Braunschweig was used. Scientists from TU Darmstadt were responsible, among other things, for the data acquisition and the time-dependent synchronization of the laser pulses, which only last a few billionths of a second (nanoseconds) with the revolution of the ions inside the storage ring. They also analyzed the data.

The specific difference in the transition wavelengths measured in hydrogen-like and lithium-like bismuth does not agree with the theoretical prediction, even when taking all known sources of systematic errors into consideration. The cause for this deviation is not known yet and is to be investigated within the scope of further measurements with other isotopes of bismuth. These isotopes are, however, radioactive and must therefore be produced before being injected into the storage ring. These possibilities are available at GSI. The new accelerator facility, FAIR, whose construction in Darmstadt will soon begin, will provide new possibilities for further investigations of this subject.

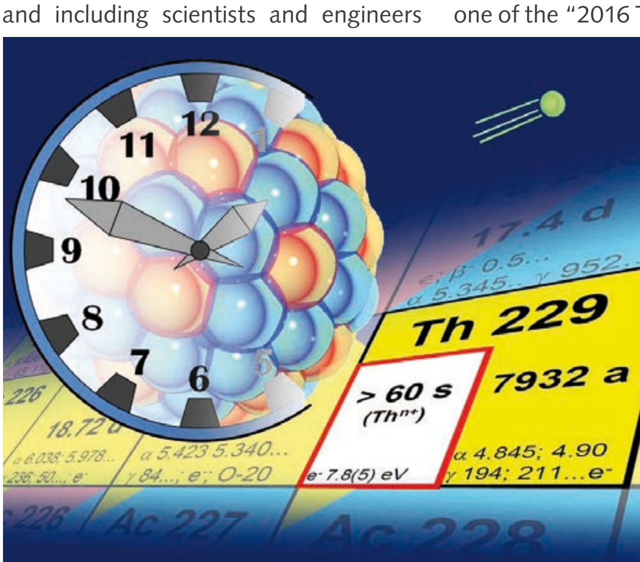


Experimental storage ring ESR at GSI.

The results published in Nature Communications are based on a cooperation project between the Westfälische Wilhelms-Universität Münster, PTB Braunschweig, the Johannes-Gutenberg-Universität Mainz, the GSI Helmholtzzentrum für Schwerionenforschung Darmstadt, and the Helmholtz-Institut Jena as well as other institutions under the leadership of the Institut für Kernphysik (Institute of Nuclear Physics) of the Technische Universität Darmstadt. ■

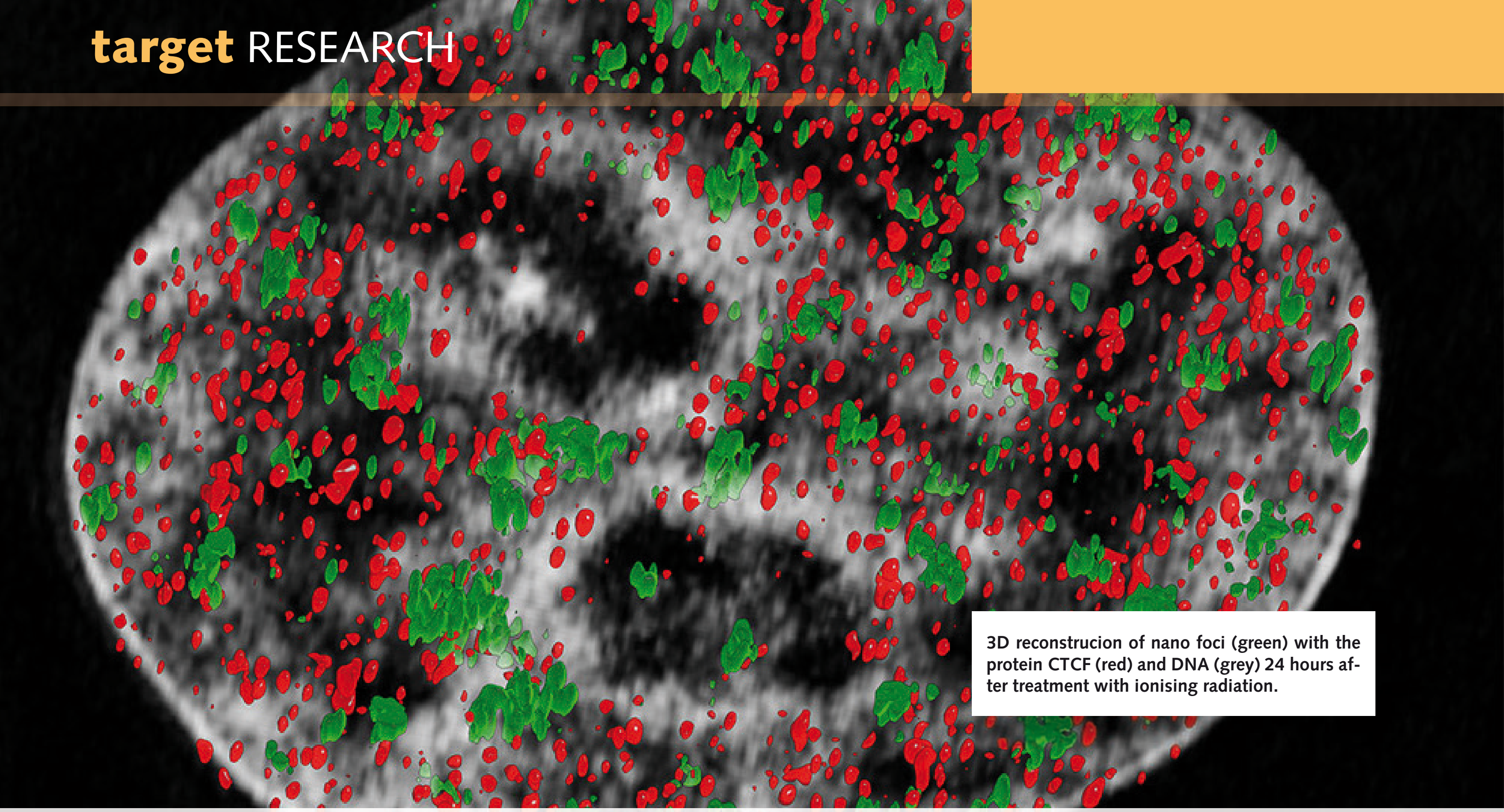
GSI scientists participate in Top 10 discovery

Scientists from GSI are participants in one of the ten most important discoveries of 2016. A publication by a team of researchers led by the Ludwig-Maximilians-Universität (LMU) in Munich and including scientists and engineers from GSI, the Helmholtz Institute Mainz (HIM), and the Johannes Gutenberg University Mainz (JGU) is among the most important breakthroughs in physics in 2016. The team's work is featured as one of the "2016 Top Ten Breakthroughs of the Year" announced in Physics World — the magazine of the British Institute of Physics. The experiments in question lay one of the foundations for the development of a nuclear clock with previously unattained precision.



Graphical illustration of the nuclear clock.

In the article, which was published in 2016, the researchers report on the first-ever direct detection of the exotic thorium isomer Th-229m. This is a decisive step that brings us closer to being able to build an ultra-precise nuclear clock based on this isomer. Atomic clocks are currently the most precise timekeepers in the world. The record is held by a clock that will keep time to within one second in 20 billion years. The team that has been commended is led by PD Dr. Peter Thirolf and Lars von der Wense from the LMU and has achieved the first experimental demonstration of an excited state of the thorium-229 isotope that had been sought worldwide for more than 40 years and could help improve the timekeeping precision by a factor of around ten. The researchers reported their findings in the scientific journal Nature. A nuclear clock features a multitude of potential applications, including the search for dark matter and gravitational waves. It would also provide ultra-high sensitivity to detect potential time variations of fundamental constants. ■



3D reconstrucion of nano foci (green) with the protein CTCF (red) and DNA (grey) 24 hours after treatment with ionising radiation.

DNA REPAIR

Identification of elementary structures

Cells use sophisticated repair mechanisms to deal with damaged genetic material. In cooperation with scientists from Munich and Berlin, researchers from Technische Universität (TU) Darmstadt and GSI recently identified one of the elementary structural units of this repair mechanism. They reported their findings in the renowned scientific journal Nature Communications.

Genetic material can be damaged during DNA replication and as a result of X-rays and other influences. In most cases, a cell's DNA repair mechanism responds to damage quickly and effectively. "The spatial organization of the genetic information in the cell nucleus plays a key role in repairing damage," says M. Cristina Cardoso, Professor of Cell Biology and Epigenetics at the Department of Biology of TU Darmstadt. In the cell nucleus, the thread-like DNA double helixes are clustered closely together with proteins. Areas containing active genes are rather loosely structured, while inactive genetic material is densely packed.

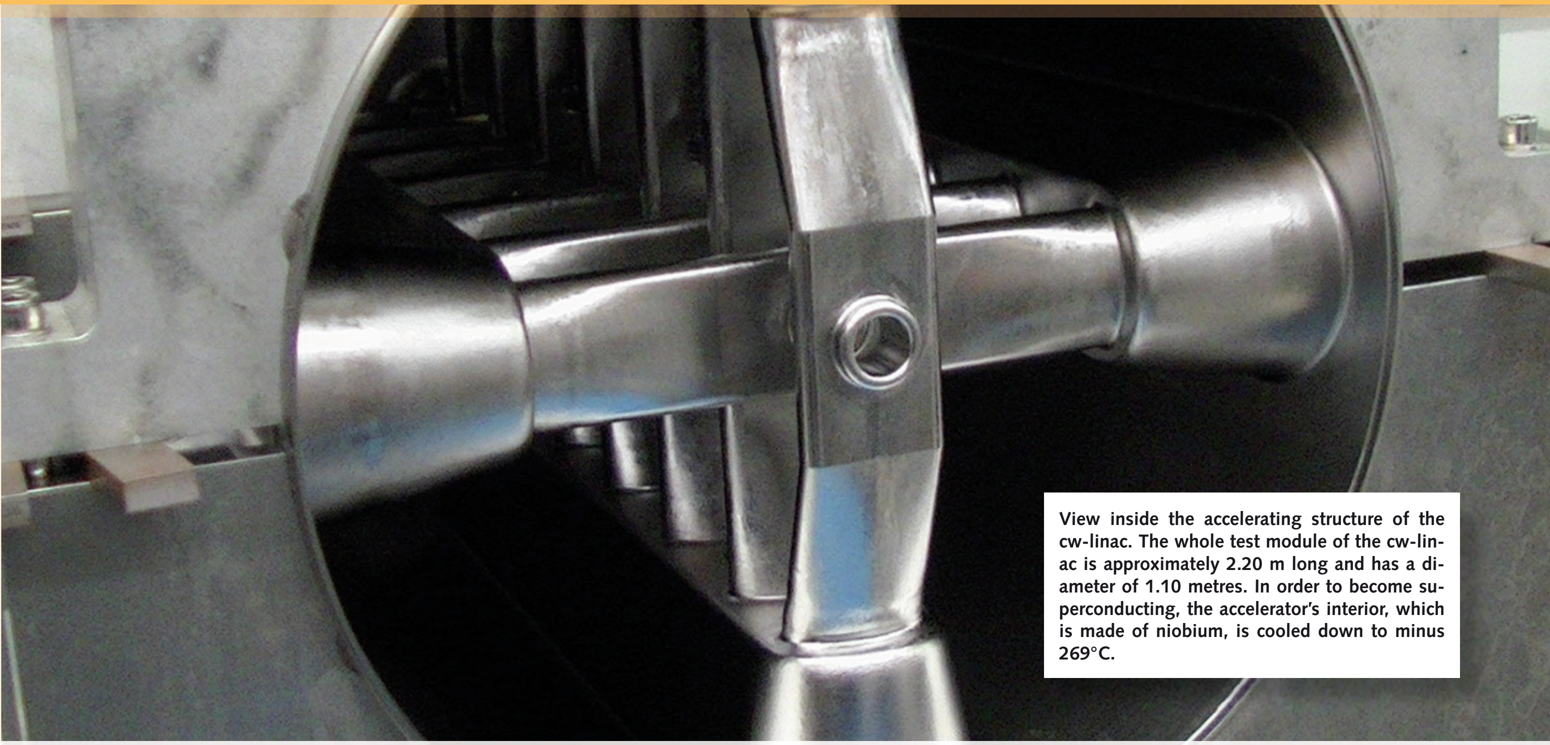
To conduct the studies that the team headed by Cardoso has published in Nature Communications, the researchers subjected human cells to X-rays in order to induce DNA double-strand breaks. Such breaks are among the most dramatic DNA defects, as they can cause cancer and other severe illnesses.

One of the first steps of the cellular repair process is the phosphorylation of a protein that is involved in the packing of DNA in the cell nucleus. Using super-resolution optical microscopy, the researchers discovered clusters composed of phosphorylated proteins and subunits of DNA clusters. These clusters, which measure only a few hundred nanometers, form tiny units, each one capable of the repair of a DNA double-strand break. When the scientists analyzed the temporal distribution of the clusters in cell nuclei, they noticed that loosely packed DNA is repaired faster than densely packed DNA. Repairs can be made more easily if the clusters of DNA strands are loosened.

The researchers also found out that the protein CTCF, which controls the spatial distribution of the DNA in the cell nucleus, plays a key role in the repair mechanism. Cells with a low CTCF content are bad at making repairs. CTCF probably stabilizes the genetic material in a form that enables it to be easily repaired.

Although the DNA in a cell nucleus may seem to be a chaotic cluster, it is actually governed by sophisticated packing and unpacking mechanisms. "It's surprising that we fully understand the molecular structure of DNA, but don't know very much about its spatial organization inside the cell nucleus," says Cardoso. That's why the current study examines not only DNA repair but also the fundamental questions regarding the arrangement of the genetic material within cell nuclei. In this way the research highlights a previously underestimated factor that has a big impact on our health.

In addition to scientists from TU Darmstadt, researchers from Ludwig-Maximilians-Universität München, the Max Delbrück Center for Molecular Medicine, Berlin, and GSI were involved in the study. ■



View inside the accelerating structure of the cw-linac. The whole test module of the cw-linac is approximately 2.20 m long and has a diameter of 1.10 metres. In order to become superconducting, the accelerator's interior, which is made of niobium, is cooled down to minus 269°C.

SUCCESSFUL DEMONSTRATION

New superconducting RF cavity

In cooperation with GSI, physicists and engineers from the Helmholtz Institute Mainz and the Goethe University Frankfurt have performed the first successful test of the novel design of a crossbar (CH) superconducting RF cavity with beam. This is one of the main milestones for the proposed superconducting continuous wave (cw) linac, which can open up new research opportunities at GSI and FAIR with its continuous beam of particles. Among other things, this makes the accelerator particularly well suited for the creation of new chemical elements.

The cw-linac demonstrator that consists of one CH-cavity was studied with beam for the first time in June and July 2017, using a beam of heavy ions at a test facility of GSI. In this test, argon ions were injected into this innovative system and accelerated. "The continuous wave linac demonstrator achieved full particle transmission and reached the target beam energy," says Dr. Winfried Barth, who heads the cw-linac development team. "The cw-linac demonstrator used an acceleration voltage of 1.6 megavolts to accelerate a heavy-ion beam with an intensity of 1.5 particle microamperes to the target energy over a distance of just 70 centimetres," said Barth, describing the success of the test. The result confirms the effectiveness and capabilities of the novel design of CH-cavity, whose development was largely funded by the Helmholtz Institute Mainz through the Acceleraor R&D programme "Matter and Technologies" by the Helmholtz Association.

Because the proposed cw-linac is to generate a continuous beam of particles, it is particularly useful for the creation and examination of superheavy elements, which is one of the traditional fields of research at GSI, the Helmholtz Institute Mainz, and the Johannes Gutenberg University Mainz. At GSI, scientists have discovered a total of six new elements and investigated their chemical and physical properties. The proposed cw-linac's continuous beam will not only benefit the heavy element programme, but also experiments in the field of materials research.

"A normally conducting accelerator would have to be much longer than the proposed superconducting cw-linac. Moreover, it would need huge amounts of energy to create such strong electromagnetic fields and it would also have to be cooled very well," says Dr. Florian Dziuba, who designed, developed, and commissioned the CH-cavity, a radio-frequency accelerator structure that is the key component of the continuous wave linac. Dziuba performed this work as part of his doctoral thesis at Goethe University in Frankfurt.

Because of its compact structure, the superconducting continuous wave linac will be able to save space and conserve considerable amounts of resources in the future. The linac is expected to accelerate ions to as much as ten per-cent of the speed of light over a distance of 13 meters. "The system's multicellular structure, which is being used here for the first time, is the most complex superconducting radio-frequency structure to have ever been built for use with an ion beam," says Dziuba, who is now employed at the Helmholtz Institute Mainz. ■

Science and Industry explore connections — Successful HEPTech event covers nanotechnology

The technology transfer network of high-energy physics HEPTech of CERN organized an academia-industry matching event on the topic of nanotechnology together with GSI on the FAIR/GSI campus. The 70 participants from eleven countries were for the first time given opportunity to exchange information in talks and discussions about potential collaboration in the application of nanotechnology in high-energy physics.

Research in nanomaterials and nanotechnology is quickly evolving worldwide and new discoveries are frequently reported in applications including nanoelectronics, sensor technologies, robotics, as well as in the energy and healthcare sector. GSI's contribution to the event highlighted the unique possibilities of heavy ions to modify materials' properties and to produce micro- and nanostructures. Examples are microfluidic systems and polymeric single-pore membranes for biosensor applications, as well as model systems for ion channels in biomembranes. Numerous other partners from science and industry reported about their results and offers during the event.

The event was organized by HEPTech and GSI in cooperation with Enterprise Europe Network Hessen. It was also supported by the transnational network NANORA. ■

Participants of the HEPTech event discuss the posters.

European funding for research on evolution of the universe

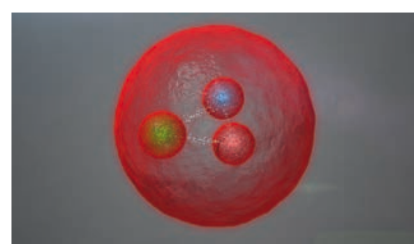
Objects like the crab nebula, a supernova remnant, can give scientists information about the evolution of the universe.

The European framework COST (European Cooperation in Science and Technology) decided to fund an Action for research on the evolution of the universe by studying the production of chemical elements in stars and stellar explosions. The Action called ChETEC (Chemical Elements as Tracers of the Evolution of the Cosmos) is supported by 29 European countries. Apart from main proposer Professor Raphael Hirschi from Keele University in Great Britain also Gabriel Martínez-Pinedo, researcher at FAIR and GSI and professor at the Technische Universität Darmstadt, is among them. The Action will provide funding to bring European research, science and business together to further our understanding of nuclear processes in the universe.

The Action will aim to maximise the scientific and innovative return of huge investments already made in experimental facilities located across Europe, including GANIL in France, the first underground laboratory for nuclear astrophysics LUNA in Italy, and the accelerator facility FAIR being constructed at GSI in Germany.

Approved by COST, the Action is one of 25 approved out of 478 eligible proposals collected earlier this year. The COST Action will provide funding for networking activities, including workshops, training schools and short-term scientific missions for four years, and will also train a new generation of European scientists, providing interdisciplinary expertise and knowledge-transfer skills. COST is supported by the EU Framework Programme Horizon 2020. ■

New particle



The LHCb experiment at the particle accelerator LHC of the European research centre CERN has reported the observation of a new particle in July 2017. The Ξ_{cc}^{++} (Xi$_{cc}^{++}$) contains two charm quarks and one up quark. Its existence was expected by current theories, but physicists have been looking for such baryons with two heavy quarks for many years. The mass of the new particle is about 3,621 mega-electronvolt, which is almost four times heavier than the most familiar baryon, the proton, a property that arises from its doubly charmed quark content. It is the first time that such a particle has been unambiguously detected. Further measurements of procuction and decay mechanisms as well as lifetime of Ξ_{cc}^{++} will help to establish how a system of two heavy quarks and a light quark behaves. The observation raises the expectations to detect other representatives of the family of doubly-heavy baryons. They will now be searched for at the LHC. ■

HIM research building inaugurated

New research building for the Helmholtz Institute Mainz.

In the presence of approximately 200 guests the new research building Structure, Symmetry and Stability of Matter and Antimatter was inaugurated in January 2017. It will host the working groups of the Helmholtz Institute Mainz (HIM). The building offers a modern and well-equipped surrounding for long-term and excellent research projects in physics and chemistry. HIM was founded in 2009 as the first Helmholtz Institute in Germany to enhance the long-standing cooperations between GSI and the Johannes Gutenberg University (JGU) in Mainz. The research building dates back to a recommendation of the Science Council from 2011. The new building was erected on the campus of the JGU in close proximity to the institutes of physics, nuclear physics and nuclear chemistry. The completion took place in summer 2016, so that a large part of the building could be inhabited already. The ferroconcrete solid building consists of a four-storey office wing, a two-storey laboratory wing and an included experimental hall with a ceiling height of up to ten metres. The main floor space of 3,600 square metres hosts research rooms, offices and workshop rooms for up to 170 employees. They have access to scientific-technical facilities including large-scale equipment like a high-performance computing centre. The total cost of 35 million Euros was funded by the German Federal Government and the State of Rhineland-Palatinate. ■

Career page of the Helmholtz Association

The Helmholtz Association has a new online career page for vacancies in sciences and science-related fields, where the open positions of the 18 Helmholtz Centres throughout Germany can be found. Science on climate change, immunology, energy transition oder supercomputing — on the new Careers Landing Page job offers from all the research areas of the Helmholtz Association are available. Currently approximately 400 jobs are vacant for talents coming from science, including numerous offers in science management. ■

More information:
www.helmholtz.de/en/careers/

Helmholtz with new Corporate Design

Since September 2017 the Helmholtz Association has a new design. Goal of the Helmholtz rebranding is a modern further development of the Helmholtz brand appearance as well as strengthening of the brand on the basis of the new fields of action in the future. Therefore a dynamic appearance with an enhanced recognition value was developed. It allows for a clear differentiation to other scientific organisations and a consistent image in all media formats ■

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

X-ray laser European XFEL inaugurated

European XFEL, the largest and most powerful X-ray laser in the world, was officially inaugurated in August 2017. Research ministers and other prominent guests from across Europe joined the European XFEL Managing Directors to officially start the research operation of the facility with the first experiments.

Professor Dr. Johanna Wanka, German Minister for Education and Research, stressed the importance of the new international research facility: "The establishment of the European XFEL has created a unique cutting-edge research facility, which promises groundbreaking insights into the nanocosmos. The foundations for tomorrow's innovations are laid by today's basic research."

The European XFEL produces extremely bright and ultrashort light pulses. The facility will generate up to 27,000 pulses per second — 200 times more than other X-ray lasers. These X-rays enable completely new insights into the atomic details and extremely fast processes of the nanoworld. Scientists will use these X-ray flashes to, for example, map the three-dimensional structure of biomolecules, and do so faster and with more detail than has ever been previously possible. Furthermore, the chronological sequence of biochemical and chemical reactions can be studied — the basis for the development of new medicines and therapies or environmentally friendlier production methods. Other applications lie in the field of materials science, in the optimization of storage media for computers or the investigation of extreme matter conditions such as those found within exoplanets. ■

Inauguration ceremony at European XFEL.

Volker Kleipa (2nd from right) discusses his idea for a new generator design based on piezo crystals with the team of Technology Transfer — from left: Dr. Tobias Engert, Dr. Martina Bauer, Elisabeth Dobesch, Tim Walz und Dr. Alicja Surowiec (r.).

Technology Transfer — From research to industry

Dr. Tobias Engert, head of the GSI staff unit Technology Transfer, and his team are about to hold an important meeting. Together with Volker Kleipa from Control Systems, Engert is seeking an investor for an innovative piezo-crystal generator. This device was invented by Kleipa, who can already present a functioning demonstrator. The goal now is to turn the concept into a usable product and market it. Engert wants to help the inventor achieve these goals.

Kleipa explains his concept as follows: "A magnetic ring rotates within a firmly mounted ring that also contains magnets. While rotating, the magnets of the inner ring repel the outside magnets, which, in turn, put pressure on the piezo crystals to make them create a voltage. In this way, rotational movement can be converted into electricity." The benefits of this technology are its low level of wear and tear, because the crystals don't age and there is no friction, and the possibility of using it in hostile environments. Engert is convinced that he will find investors who are interested in the concept.

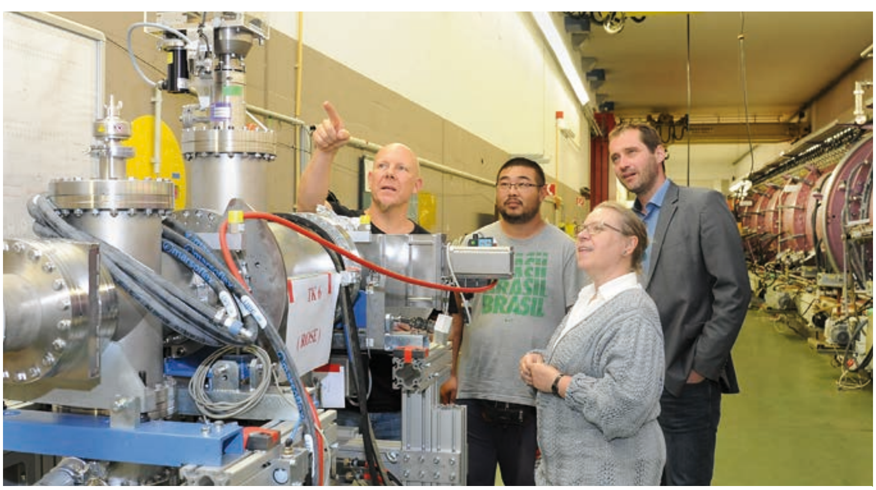
"In addition to producing research results, we also create new technologies. We very much want to launch them on the market, because they create and secure jobs that generate tax income, which in turn also flows back into research and development activities," says Engert about the technology transfer cycle. "Our job is to discover and evaluate these technologies and to find business partners for marketing them so that the technologies can be transferred. This benefits the industrial partner, the inventor, GSI, FAIR, and of course society as a whole."

There are plenty of ideas at the FAIR/GSI Campus, as demonstrated by the approximately 630 patents that are currently registered. Not all of these ideas are immediately marketable, and they often have to go through a variety of intermediate steps. "Sometimes there is simply an idea or a functioning demonstrator, as is the case with Volker Kleipa's invention," says Engert. "In such cases, the concept still has to be developed into a finished product. We are soliciting third-party funding for this purpose and persuading companies, many of them medium-size businesses, to support the process so that the result can be marketed later on. Sometimes scientists aim to market their products themselves. Such spin-offs are the ultimate form of technology transfer, because they support not only product development but also the creation of new companies."

Networking is crucial for technology transfer. New ideas have to be made known in professional circles, and appropriate companies must be found for marketing the results. For the right partners to come together, it's essential to have close contact with many potential licensees and to hold extensive discussions between researchers and industry. For this purpose, the Technology Transfer staff unit organizes discussion-focused „Industry Meets Academia" events as well as roadshows where company representatives can talk with scientists at the FAIR/GSI Campus.

Another success story is an innovative system for measuring emittance, which is the volume that an ion beam occupies in the phase space. Information about the ions' emittance and manipulation of it in the accelerator are relevant for the beam quality. So far, emittance has been determined in two directions in space, using two rigidly mounted measurement devices. However, these measurements lack certain pieces of information. In response, GSI researchers Dr. Michael Maier and Dr. Chen Xiao have come up with ROSE (ROtating System for Emittance measurement). This device can measure emittance at additional angles in order to complete the available information. Because the device can be rotated, it can cover all directions in space, eliminating the need for one of the measuring planes. Because the rotary drive costs much less than the measurement device itself, the new system reduces the production costs of the entire system. A patent has been issued for it, and the Technology Transfer staff unit has helped to find a marketing partner from industry. A patent license will enable both of the inventors as well as GSI, as the source of the innovation, to earn a share of the resulting profits.

Besides being a trained car mechanic, Engert has degrees in mechanical engineering and physics, a PhD in nuclear physics, and a patent engineer title. That makes him the ideal person for the task of transferring innovations from the FAIR and GSI research departments to industry. Engert's four-person team consists of a physicist, a biologist, a team assistant, and a university student. He has headed this department since 2013. Cooperation with industrial partners has steadily improved since then, and the staff unit now has 75 marketing partnerships. Besides ROSE and the piezo generator, the energy-saving water cooling technology used for the maximum-performance Green IT Cube computer centre and the minimal-stress carbon-ion tumor treatment method are just a few examples of the innovations that have been created. "This number will continue to increase," says Engert. "Major projects such as FAIR have a noticeable influence on the regions where they are implemented. The best-known example of this is California, where Stanford University created a technology park in the 1950s that has since then evolved into Silicon Valley. FAIR harbors great potential in this regard, and we definitely want to exploit it." ■



Dr. Tobias Engert (r.) and Dr. Alicja Surowiec from Technology Transfer take a look at the ROSE prototype, a development of Dr. Michael Maier (l.) und Dr. Chen Xiao (2nd f. l.), which improves the measurement of emittance of the ion beam, at the GSI linear accelerator UNILAC.

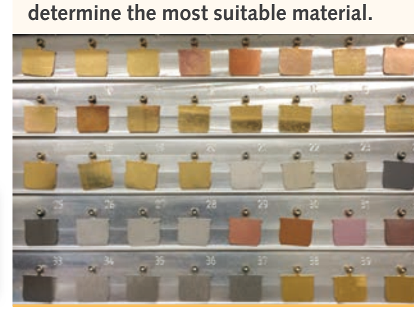
Targets at GSI

A variety of targets is used in the FAIR and GSI accelerator experiments. In each issue of the magazine we will present one of them in detail.

Preserving the vacuum

Gases are emitted when ions hit surfaces in an accelerator. These gases downgrade the vacuum inside the accelerator and can cause beam loss. As a result, it's important to keep gas emission low at FAIR and other accelerator facilities worldwide. The emission can be minimized by using special surfaces and surface treatments. In their search for the best materials for this purpose, the scientists test many samples that have been prepared with different manufacturing techniques and under a variety of conditions. The researchers bombard these samples with ions and measure the resulting gas emission. They are looking for a material that has a high level of electrical and thermal conductivity so that the heat imparted to the sample by the ion is quickly dissipated. The best candidate they have found to date is gold-plated copper.

Targets made of gold-plated copper, tungsten, stainless steel, and copper oxide to determine the most suitable material.



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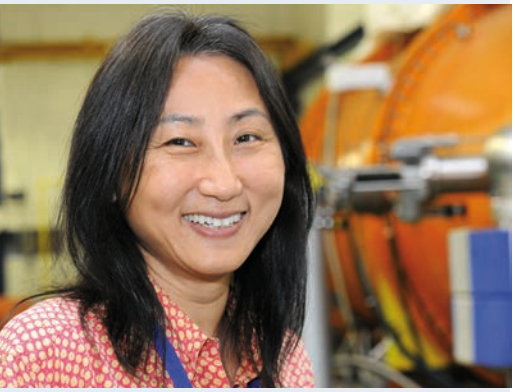
GSI Helmholtzzentrum für Schwerionenforschung operates a unique large-scale accelerator. Researchers from around the world use this facility for experiments on the building blocks of matter and the evolution of the universe. Currently the accelerator facility FAIR is being built in international cooperation.

NEW APPOINTMENTS

Mei Bai is new head of accelerator operations division



Since May 1, 2017, professor Mei Bai is the new head of the accelerator operations division. Before this, the division was led by Dr. Udo Weinrich as the interim head, who did an excellent job in leading the organization during the transition period.

Bai is a well-known expert in accelerator physics and technology. She studied engineering and physics in Chengdu and Hefei, China. She gained her PhD at the Indiana University in Bloomington, USA. Subsequently she was employed at the Brookhaven National Laboratory in Upton, USA, and as adjunct professor at the Stony Brook University, USA. Since 2014 she is professor for experimental physics at the University Bonn, Germany. At the same time and up to her transition to FAIR/GSI she additionally held the position of head of the Institute of Large Scale Nuclear Physics Equipment at the research centre Jülich, Germany.

FAIR and GSI in social media

Scan the QR code with your mobile phone to open the link to our social media website.

Three scientists honored with the Christoph Schmelzer Award 2017

This year's Christoph Schmelzer Award has been granted to three young scientists. **Lennart Volz** (2. v. l.) from the German Cancer Research Center (DKFZ) in Heidelberg, **Dr. Johannes Petzoldt** (l.) from the IBA Group in Louvain-la-Neuve (Belgium), and **Dr. Kristjan Anderle** (r.) from the GSI were presented with the award in November 2017 at the GSI campus in Darmstadt. The Association for the Promotion of Tumor Therapy with Heavy Ions presents this award annually in recognition of outstanding master's and doctoral theses in the field of tumor therapy with heavy ions. The awards, which were presented this year for the 19th time, are named after Professor Christoph Schmelzer, the co-founder and first Scientific Director of GSI.

Yoshiki Tanaka receives FAIR-GENCO-Award for young scientists

This year's FAIR-GENCO Young Scientist Award goes to **Dr. Yoshiki Tanaka (m.)** from the University of Tokio. The award is sponsored by the FAIR-GSI Exotic Nuclei Community (GENCO) and endowed with 1,000 Euro. The bestowal by GENCO president Professor Dr. Christoph Scheidenberger (l.) and vice-president Professor Dr. Nasser Kalantar-Nayestanaki took place in March 2017 in a special colloquium in the framework of the yearly GENCO meeting at FAIR and GSI. Dr. Tanaka searched for bound states of so-called Eta' mesons with carbon atoms in a novel experiment at the GSI fragment separator FRS. The existence of these bound states is theoretically predicted and already for many years experiments are conducted to find them. Although bound states were not observed in Dr. Tanakas experiment yet, by putting upper bounds on the formation cross section he succeeded for the first time to draw quantitative conclusions on the strength of the interaction of both particles and the binding forces taking effect in the process. This advance leads to an improvement of the theoretical understanding and gives target-oriented indications for the design of detectors and experiments for the further search. It is therefore perceived as an important milestone on the way to the discovery among the experts.

CBM PhD Award for Dr. Maksym Zyzak

For the second time the CBM PhD Award was handed over in March. **Dr. Maksym Zyzak** (l.) of GSI received the award for his PhD thesis at the University of Frankfurt. The award was presented during the CBM Collaboration Meeting at GSI by the spokesperson of the award committee Dr. Andrej Kugler. The award is endowed with a prize money of 500 Euros. In his PhD thesis „Online selection of short-lived particles on many-core computer architectures in the CBM experiment at FAIR" Zyzak developed software for the fast identification of short-lived particles produced in heavy ion collisions by their decay products. This is of great importance to the CBM experiments for the selection of rare events in real time. The software packet „KFParticleFinder" developed by the awardee analyses more than 100 different decay channels at the same time by employing parallel computing. Apart from its future use in CBM the packet is already in use by currently running experiments (STAR, ALICE).

PANDA PhD Prize for Erik Etzelmüller

Dr. Erik Etzelmüller has received the PANDA PhD Prize 2017 for his doctoral thesis at GSI, FAIR, and the Justus Liebig University in Gießen. The award was presented by the spokesman of the Panda Collaboration, Klaus Peters from GSI, at the Panda Collaboration meeting at the BINP in Novosibirsk. Physicist Erik Etzelmüller, 30, received the prize of €200 and a certificate for his dissertation titled "Developments towards the technical design and prototype of the PANDA Endcap Disc DIRC". His doctoral advisor was Professor Dr. Michael Düren from the Justus Liebig University in Gießen. The Panda Collaboration has awarded the PhD Prize once per year since 2013 in order to honour the best dissertation written in connection with the Panda Experiment. Panda will be one of the key experiments of the future accelerator centre FAIR. The experiment focuses on antimatter research as well as on various topics related to the weak and the strong force, exotic states of matter, and the structure of hadrons. More than 500 scientists from 17 countries currently work in the Panda Collaboration.