HZB Helmholtz Zentrum Berlin

lichtblick

SPECIAL EDITION | SEPTEMBER 2023

25 Years of BESSY II: A Success Story in Berlin-Adlershof

EN


Picture: Dirk Laubner

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IMPRINT

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Klimaneutral Druckprodukt
ClimatePartner.com/15682-2308-1007

THREE QUESTIONS FOR BERND RECH

25 years of BESSY II – a success story

BESSY II has now been in operation for 25 years. Why is this a reason to celebrate for HZB and the community?

Bernd Rech: BESSY II has delivered 25 years of spectacular scientific results and important contributions to technological breakthroughs. Research at BESSY II has enabled countless careers, and has always been a magnet for international scientific exchange and a sought-after cooperation partner. BESSY II has played a major role in the development of the Science and Technology Park in Berlin-Adlershof. Numerous high-profile visits, especially in recent times, are testimony that BESSY II is currently right up high on the "top list of places to see". That is a very long list, and we certainly have 1001 reasons to celebrate.

What birthday present do you think HZB would like the most for BESSY's anniversary?

A commitment from the Federal Ministry of Education and Research for our BESSY II+ upgrade project, which will keep the facility at the cutting edge of technology. It would enable us to continue the exceptional research at BESSY II into the 2030s. Also the best gift to us would be for the users of BESSY II to carry the spirit of the last 25 years into the next decade and all the way to BESSY III.

What has to happen in the next ten years to ensure that top-level research with synchrotron radiation can continue in Berlin?

We have to continue on the path we have taken and develop HZB into a world-leading energy materials research centre that delivers outstanding scientific results. We can do this with the best minds in science, technology and administration. We need top infrastructures – especially, but not limited to, BESSY II+, a commitment to BESSY III, and excellent partnerships in the Berlin area and with national and international partners.

Interviewed by Silvia Zerbe.

Brilliant light for research

Picture: Phil Dera

A MAGNIFICENT TEAM KEEPS EVERYTHING GOING SMOOTHLY AT BESSY II

Many colleagues – way more than appear in the photo – work together to make BESSY II one of the most reliable synchrotron radiation sources in the world.

Picture: Phil Dera

TITLE STORY

The physics professor with the screwdriver

Andreas Jankowiak and his team have been keeping BESSY II operating smoothly for more than ten years. Since the beginning of his career, he has been driven by a passion for physics – and a love of technology.

When Andreas Jankowiak first came to Adlershof, he was driving an old VW Golf. This was when he was a doctoral student in 1998, and he was making the 500 kilometre trip from the University of Dortmund together with a fellow student. “One of the magnetic loops at our accelerator in Dortmund had broken,” he recalls, “and our colleagues in Berlin had five of them in stock.” The campus in Adlershof was still largely undeveloped at the time. BESSY II was in the midst of being commissioned and Jankowiak, at the wheel of his old student car, had no idea that he would one day become the director of the Institute for Accelerator Operation, Development and Technology.

It was a nascent era not only for accelerator technology, but also for the budding physicist Andreas Jankowiak. How fitting it was for the student that Dortmund was being considered at the time as the location for the European Synchrotron Radiation Facility! The university in the Ruhr region was

Picture: Silvia Steinbach

Looking into the heart of the storage ring: this is where the electrons race in a circle and emit their coveted light for research.

not far from his hometown of Recklinghausen, and in anticipation of the major investment, it appointed Klaus Wille as the first professor of accelerator physics, who would hence-forth give lectures.

"It was a field that was made for me, I realised right away," Jankowiak relates. "It was about fundamental physics, but it was combined with technology." And although the large-scale research facility was ultimately built in Grenoble and not in Dortmund, he had already been captivated by the special field.

Today, Jankowiak has long since become a Berliner, even if the lilt of his Westphalian accent still comes through in his speech. His favourite place is in the accelerator hall: he likes the concentrated atmosphere among his colleagues who are working there on the accelerator and their experiments. Another place he likes is the control room: "It's best when it's empty in there," says the 55-year-old with a laugh. "Then I know the machine is working flawlessly in the background!" A counter at the facility measures the time, to the minute, during which everything runs as planned. Ensuring smooth operation is one of Jankowiak's most important tasks. The goal of keeping BESSY II available for 99 percent of the planned time keeps his entire team busy – "out of the 5,000 hours per year, we want to fail for no more than 50 hours in delivering the beam as promised."

And this ambitious goal is indeed a job for a full team: 110 experts at the institute are

working to operate the storage ring and to develop new possibilities. They work in close cooperation with colleagues from other institutes, from facility management and from IT. The work is so varied that some of the components in the huge facility have only one or two experts responsible for them – with the tasks therefore spread over numerous shoulders – and all the many different threads come together at Andreas Jankowiak. Planning and discussions take place on the regular jour fixe, and when major challenges arise, the team convenes special workshops.

One of these major tasks has recently dominated the agenda: the planning of BESSY III, the successor to the current radiation source. “This will be of a completely different order of magnitude than anything else we have built at HZB so far,” says Andreas Jankowiak. That makes the task especially complex, and he and his team are providing essential impetus for the planning phase. “For me, this is the biggest challenge I have ever worked on,” he says.

Picture: PhilDera

ON A BRIEF VISIT TO THE BESSY CONTROL ROOM

“It’s best when it’s empty in the control room. Then I know the machine is working flawlessly in the background!”

Andreas Jankowiak

In fact, his career has been a succession of ever larger construction sites. It all started back in Dortmund: although the large-scale European facility was ultimately not built there, they did get a smaller accelerator called DELTA (“Dortmund Electron Test Accelerator”). “When I first got there, it was nothing

> “BESSY III will be of a completely different order of magnitude than anything else we have built at HZB so far. For me, this is the biggest challenge I have ever worked on.”
>
> **Andreas Jankowiak**

but a big hall with a smooth floor,” Jankowiak recalls. And the young physicist seized every opportunity that came his way: while the facility in the hall continued to grow, he wrote his diploma thesis on the “calibration of delta beam position monitors”, and even stayed in Dortmund for his doctoral thesis. “The core team consisted of only a handful of people, who couldn’t possibly manage everything,” he recalls. “Those who were prepared to take responsibility simply grabbed whatever tools were lying around and got right to it. It was a really great time!” Jankowiak pauses for a moment, then has to laugh: “Of course, it wasn’t conducive to doing your PhD quickly, because you could lose yourself for any length of time in all the absorbing tasks that came up everywhere.” He spent six years on his doctorate, during which time he became the head of the High-Frequency Group at Delta. The experiences from this phase were to become formative for him – as it was for many other young physicists who would go on to become responsible for larger facilities all over the world.

FROM MAINZ TO BERLIN

In 2000, straight after earning his PhD, Andreas Jankowiak moved to Mainz. There he joined the operating team of the electron accelerator MAMI B and, in 2005, became the operations manager of the Mainz microtron. How well the physicist performed his duties did not go unnoticed – he was offered the position of Operations Director at the Thomas Jefferson National Accelerator Facility in the USA. He ended up turning it down: “For one thing, I had a permanent position as a research assistant in Mainz, and those were almost rarer than a professorship,” he says with a smile, and then adds: “Besides, our daughter was still small, and my wife had got exactly the half-time position she was looking for at the university in Mainz.” She works in the civil service, Andreas Jankowiak met her when he was doing his A-levels in Recklinghausen.

But in 2010, when he was offered a professorship at Humboldt University Berlin and a position as chief scientist at HZB, he accepted. “At DELTA in Dortmund I had five employees, in Mainz 20 to 25, and in Berlin it turned out that there would be 80 to 100 people. That seemed like a logical progression to me,” says Jankowiak.

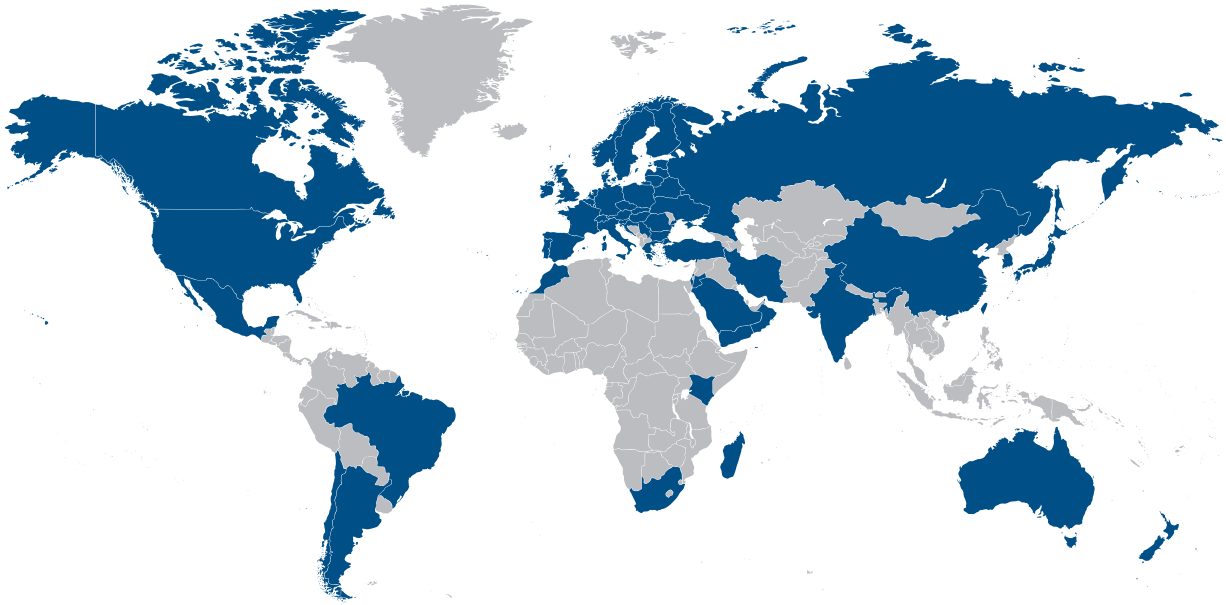
THE COOPERATION OF A MOTIVATED TEAM

In fact, it was mainly because of the team that he agreed to join: working with a motivated team, he says, is what he enjoys most. And, of course, the strategic thinking that always plays a big part in the continuing development of BESSY II. Jankowiak’s strength is that he recognises trends early on and inspires his colleagues to follow them.

Andreas Jankowiak has come to terms with the fact that his job is mainly managerial. Sometimes, however, he will leave his office to go to the control room or the experimental halls of the test facilities and talk to his colleagues about the things they are currently working on. “And when we come up with ideas together on how to refine the experiments or better understand observations,” he says, “then those are the really beautiful moments.”

■ BY KILIAN KIRCHGESSNER

THE WORLD AS A GUEST AT BESSY II



58

countries, the number of nations that have applied for beamtime at BESSY II. New guests in 2023: Lithuania, Iran, Kenya, Madagascar.

Light sources like BESSY II are a veritable hub for ideas from all over the world. Guest researchers come from many countries and continents to perform experiments at BESSY II. Long before the term science diplomacy was coined, researchers at the BESSY beamlines were working together as equals and advancing the understanding between cultures.

Science diplomacy is a central topic for Antje Vollmer, spokesperson for BESSY II. One of her inspirations was a lecture by Rolf-Dieter Heuer, former Director General of CERN, who described how important large-scale research facilities are for international cooperation and for science diplomacy. She herself has travelled to many universities in Southern and Eastern Europe as part of the CALIPSO programme, given lectures, and invited young researchers to submit experimental proposals to BESSY II and other synchrotrons. Over the years, the staff at BESSY II have established international collaborations, for example with SESAME in Jordan and with accelerator centres in the USA. BESSY II has always been an international meeting place that stands for openness and diversity. This was demonstrated once again at this year's user meeting, for example, when a Kenyan delegation was visiting (see p. 18). Antje Vollmer underlines: "I think it's a great opportunity to collaborate on scientific projects with partners from all over the world, with whom we can share ideas and infrastructures." (sz/fk)

1995

BESSY I received comparatively few guest researchers from other countries, as the map from 1995 shows. When its user office was established, the number of international relationships grew rapidly.

25 YEARS OF BESSY II – A SUCCESS STORY IN FIGURES

11 000 +

registered **users** performing experiments at BESSY II

30 000 +

applications for beamtime at BESSY II (proposals) from 58 countries in the last ten years

12 000 +

publications based on experiments performed at BESSY II

38 000 +

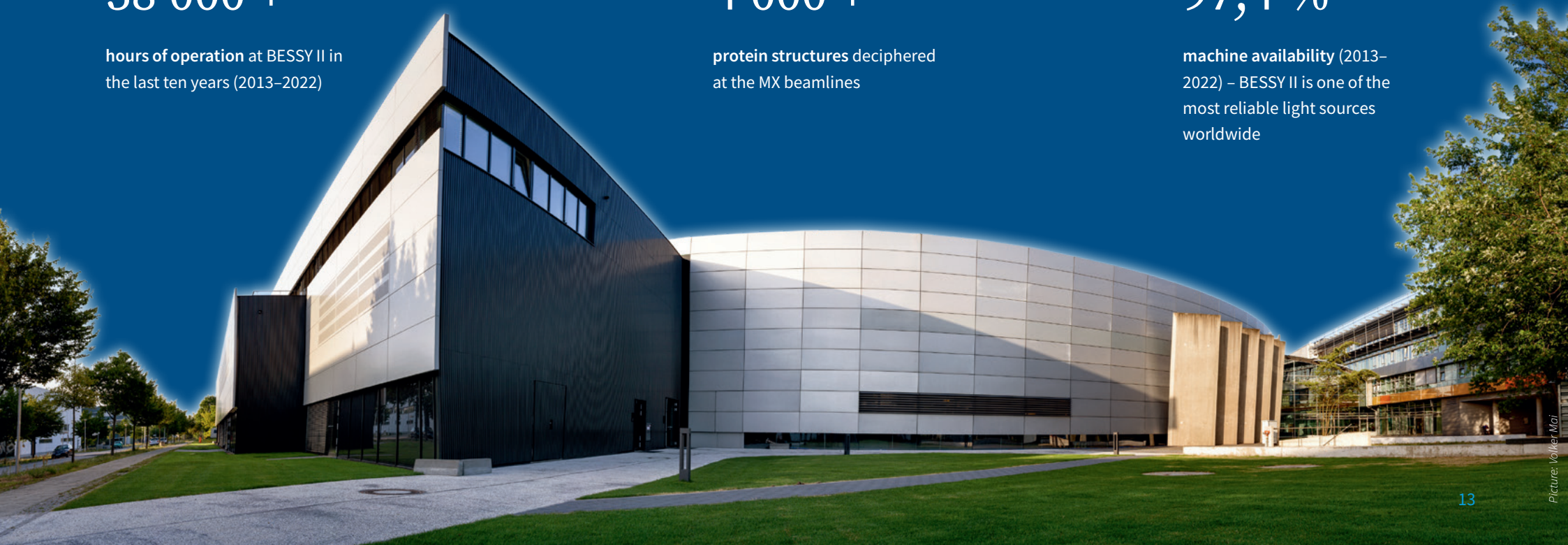
hours of operation at BESSY II in the last ten years (2013–2022)

4 000 +

protein structures deciphered at the MX beamlines

97,4 %

machine availability (2013–2022) – BESSY II is one of the most reliable light sources worldwide



Picture: Volker Mai

How BESSY II came to Adlershof

In December 1981, BESSY I went into operation; it is Germany's first dedicated synchrotron radiation source. With a circumference of 60 metres, the storage ring was designed to be relatively compact so that it could be built in Berlin-Wilmersdorf by “Berliner Elektronen- Speicherring Gesellschaft für Synchrotronstrahlung GmbH (BESSY)”. Spectrometers for the Soho solar probe and detectors for the Chandra space telescope are just two examples of instruments that were calibrated here. In 1986, Ernst-Eckhard Koch, the Director of BESSY, came across a concept for a light source of the 3rd generation, which was state-of-the-art at the time. But there was no way it would fit into Wilmersdorf.

This problem would finally be resolved with the reunification of East and West Germany: on the former grounds of the Academy of Sciences in Adlershof, they found the perfect site for BESSY II, an electron storage ring with a circumference of 240 metres. The project was launched under the leadership of Eberhard Jaeschke, and construction started in 1993. The core team of BESSY accomplished the amazing feat of continuing to operate

60

metres in circumference:
due to its size, BESSY I in Berlin-Wilmersdorf very quickly reached its limits.

1981–1999

The location of BESSY I in Berlin-Wilmersdorf is simply too small. With German reunification comes the opportunity to rebuild in Adlershof.

1994

The location Berlin-Adlershof at the beginning of the 1990s: there is plenty of space on the former premises of East Germany’s Academy of Sciences.

1994

Groundbreaking ceremony of BESSY II: thanks to many active supporters in politics and science, the way is clear for constructing BESSY II.

1995

Excavators and cranes roll in to dig the ground for the storage ring.

BESSY I in Wilmersdorf at the same time as building BESSY II in Adlershof. After four years of construction, the new high brilliancy synchrotron radiation source BESSY II went into operation in September 1998, and user operation began in 1999.

Also in 1999, BESSY I was shut down and dismantled. In the scope of a UNESCO project, components of the old accelerator were shipped to Jordan and later used in the SESAME light source. The accelerator team of BESSY II built yet another light source in the vicinity of BESSY II: the Metrology Light Source (MLS) of the Physikalisch-Technische Bundesanstalt (PTB).

With its focus on soft X-ray light, BESSY II is the only one of its kind in Germany and complements other light sources such as PETRA III at DESY. BESSY II generates high-brightness X-ray pulses for research with extreme reliability and quality. Every year, HZB receives 2 700 visits from guest researchers, who come from all over the world to study their samples at BESSY II.

■ BY ANTONIA RÖTGER

240

metres in circumference:
BESSY II is much bigger than its predecessor. More space means more beamlines and experiments and greater scientific output.

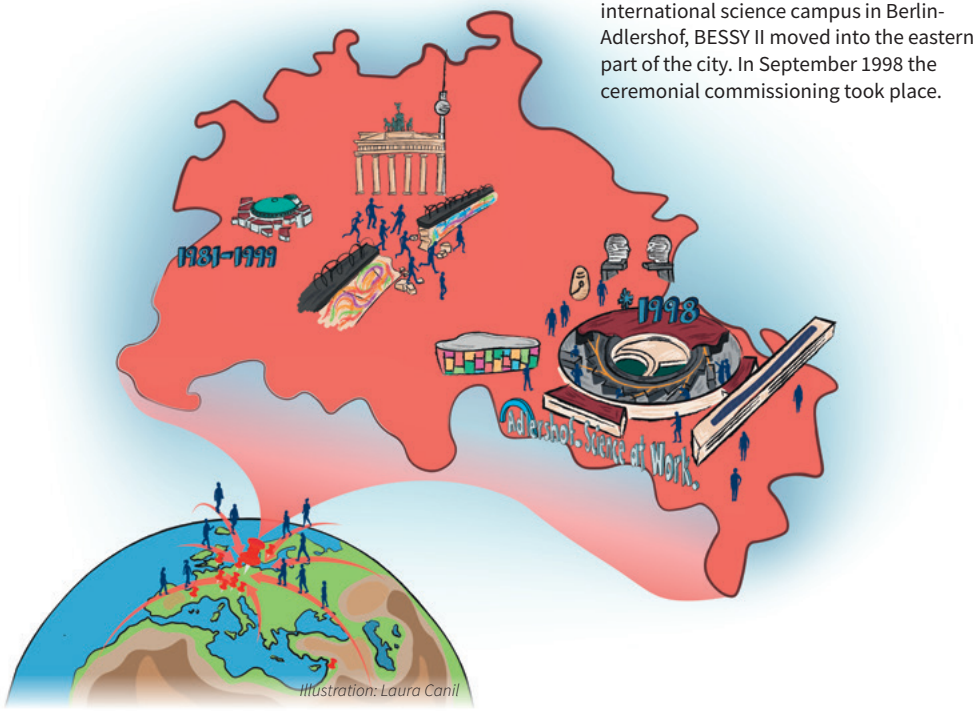
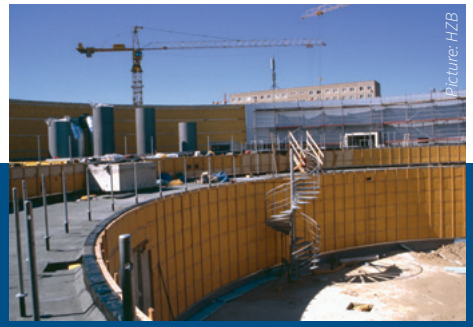


Illustration: Laura Canil

Moving West to East: with the fall of the Wall and with the political will to build an international science campus in Berlin-Adlershof, BESSY II moved into the eastern part of the city. In September 1998 the ceremonial commissioning took place.

1995


Picture: HZB

The storage ring, with its circumference of 240 metres, continues to take shape.

4. September 1998


Picture: HZB

After only four years' construction time, BESSY II is complete . The ceremonial commissioning takes place in September – a spark that sets off the development of Adlershof.

1998


Picture: HZB

The interior finishing of the still mostly empty experimental hall picks up speed. New ideas for experiments are born.

2016


Photo: Wenke Seemann

The "Energy Materials In-Situ Laboratory Berlin" (EMIL) is built as an extension to BESSY II. Federal Minister of Research Johanna Wanka (left) with Robert Schlögl (MPG) and Simone Raoux (HZB).

HAPPY Birthday BESSY II


Picture: Bundesregierung/Guido Bergmann

»I congratulate Helmholtz-Zentrum Berlin für Materialien und Energie for the 25 extraordinarily successful years of its synchrotron BESSY II. Its strong pulses of synchrotron light give us insights into materials such as the special layers used in modern storage media or solar cells, which are only a few nanometres thick. They form the basis for many applications in science and industry.
BESSY II has become the centre of a very productive science campus. The Federal Ministry of Education and Research has strongly supported this development and will of course continue to support this highly relevant research infrastructure.«

Bettina Stark-Watzinger
Federal Minister of Education and Research


Picture: Hans Christian Plambeck

»I congratulate you on the 25th anniversary of BESSY II and wish you exciting experiments and great scientific breakthroughs in the years to come, from which we as a society can all benefit. Keep on building your relationship with the world and the public and sharing this enthusiasm for the research you are doing. We need people like you to show how important research is in our everyday lives. I wish you and your teams much energy, curiosity and enthusiasm in what you do!«

Ina Czyborra
Senator for Science, Health and Care in Berlin

»For now 25 years, BESSY II has been a hub of creativity in accelerator technology and the use of synchrotron radiation. At this respectable age for a facility, it is still a vibrant scientific center with impressive contributions in energy research, quantum and functional materials and health. Being grounded in HZB is a unique asset in shaping its future, fully recognised in the Center's strategy.
On behalf of SAC, I wish BESSY II a new youth with the BESSY II+ project before a successful reincarnation as BESSY III.«

Jean Daillant
Director general of SOLEIL and chair of SAC (Scientific Advisory Committee)

»Dear BESSY II, congratulations on your 25th anniversary! Your partnership with our institute is invaluable because the 'brightest light in Berlin' that you provide is the irreplaceable source of light that drives materials research and contributes to a safer and greener Germany. With the BAMline, we will continue to gain new insights and pave the way for transformative discoveries.«

Franziska Emmerling and Ulrich Panne
Head of Structure Analysis and President of the Federal Institute for Materials Research and Testing (BAM)

»The application of synchrotron radiation is a success story – not least for metrology.
With this technology, research into innovative materials for the semiconductor industry, battery production or space-based astronomy can be transferred directly into the economy and society.
I am therefore looking forward to the continued strategic cooperation between HZB and PTB as much as to the future upgrade from BESSY II to BESSY III. In particular, quantitative measurements with synchrotron radiation will make it possible to investigate complex and structured materials directly 'in operando' – a paradigm shift in metrology that promises extraordinary innovations for a sustainable, healthy and climate-neutral future.«

Cornelia Denz
President of the Physikalisch-Technische Bundesanstalt (PTB)

Picture: Michael Setzpfandt

User meeting 2023 with country of honour Kenya: “We need our own light source in Africa. We have so many talented young people.”

Lucy Ombaka

A delegation from Kenya attended the BESSY@HZB user meeting and sat in on the experiments at the beamlines.

Light sources for peace and prosperity

How does science diplomacy work? The public panel discussion at this year's User Meeting in June asked what contribution large-scale translational research institutions such as CERN, SESAME and a future African light source can make to peace. The lively discussion resonated for a long time.

Rolf Heuer, Director General of CERN from 2005 to 2019, began by recalling the state of Europe after the Second World War: so many cities were destroyed; what needed to be done? Just share out food? That wouldn't have been enough to help Europe to flourish again. "A handful of visionary, well-connected researchers and politicians at the time founded the Conseil Européen pour la Recherche Nucléaire (CERN)," Heuer recounted. Today, it is hard to imagine how high the hurdles must have been for this research centre in that period: CERN was to be a place for conducting joint research into the fascinating questions of nuclear and particle physics. Back then, people from enemy nations such as Germany and France first had to relearn to work together. Now, non-European countries such as Israel have also become members of CERN, and others such as Pakistan and India are associate members. "At CERN, we talk openly and confidently about research – without hidden agendas. That is diplomacy through research," Heuer explained.

"Your past is our present," said Gihan Kamel of SESAME. This light source facility received help from Europe in getting started: in 2002, for example, accelerator components from the dismantled BESSY I were shipped to Jordan and installed in SESAME. In 2022, the Helmholtz-SESAME soft X-ray beamline, for which HZB built the undulator, went into operation. Other light sources also assisted by providing training and components. Now, there are five beamlines where teams, even from feuding countries, conduct joint research. "When I go to work in the morning, I deliberately don't read the news, because we often have very different perspectives on politics. But we still work well together," said the Egyptian biophysicist Kamel. Especially important is the fact that "SESAME not only creates trust; it also helps us to reverse the brain drain. Now, talented young people are coming back from abroad again because they want to work at SESAME." SESAME already

Picture: Mrchael Setzpfandt

Those in the panel discussion: (from the left) Gihan Kamel (SESAME), Sekazi Mtingwa (LAAAMP), Rolf Heuer (CERN and SESAME), Yazmin Lucero Cobos Becerra (HZB) und Lucy Ombaka (Technical University Kenya). Moderation by Rutger Schlattmann (HZB, 3rd from the right). The welcome address was made by the Berlin Senator for Science Ina Czyborra (left).

has a worldwide unique selling point: the light source is powered entirely by solar energy. This is an important point, because the sun does not charge for its power.

"We also need our own light source in Africa," emphasised physicist Lucy Ombaka of the Kenyan delegation, which visited HZB in June to become acquainted with the research possibilities. "Because Africa is not poor: we have so many talented young people and natural resources. A light source would motivate the young generation to come back after spending time abroad and contribute to making innovations here," says the researcher. Physicist Sekazi Mtingwa agreed with her. He has been campaigning for an African light source for years and, as Chairman of LAAAMP, is organising political support for it. "We could achieve so much more if we directed our research towards increasing health and prosperity." He advocated in favour of a fourth generation African Light Source, which would be jointly funded by the Member States of the African Union. Applications have already been submitted: "We can only convince policymakers in matters of the socioeconomic impact, and we have very good arguments for this," said the experienced science manager. Yazmin Lucero Cobos Becerra agrees with him. She is coordinating the Green-QUEST project for HZB, which aims to promote the sustainable production of green liquefied fuel gas in Southern Africa. When research directly addresses societal needs, it is easier to find funders. "It is important that we work together as equals in all our projects," says the HZB researcher.

■ BY ANTONIA RÖTGER

"When I go to work in the morning, I deliberately don't read the news, because we often have very different perspectives on politics. But we still work well together."

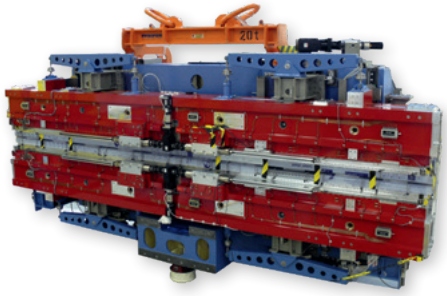
Gihan Kamel, biophysicist (SESAME)

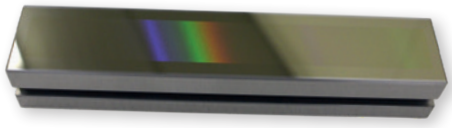
"At CERN, we talk openly and confidently about research – without hidden agendas. That is diplomacy through research."

Rolf Heuer (CERN and SESAME)

TWO EXAMPLES OF ACTIVE KNOWLEDGE TRANSFER

From HZB to the world: technologies in demand





UNDULATORS

Undulators are a core component of synchrotron radiation sources. They consist of dipole magnets cleverly aligned in a way that forces the electron beam into wavelike motion. This makes the beam emit light that becomes superimposed into high-brightness synchrotron radiation.

BESSY II was the first storage ring of the third generation using so-called APPLE II undulators. Competence in this technology is in worldwide demand. In 2000, for example, the Swiss Light Source of PSI built its first APPLE II undulators with the support of BESSY. Later, a cryogenic permanent magnet undulator was successfully built for MAMI in Mainz and UCLA in Los Angeles. The longest APPLE II undulator, at five metres in length, was built for PETRA III in Hamburg. The HZB team also developed a double undulator system that can generate femtosecond pulses of circular polarised light. The entire undulator system was built at MAX IV in Lund.

Currently, the undulator team is working on developing more compact and affordable undulators in the scope of the Helmholtz ATHENA project. A prototype already exists, and has met with great interest from other light sources.

DIFFRACTION GRATINGS

A simple glass prism is all it takes to split sunlight into multiple colours.Light sources also deliver a colourful blend of wavelengths, but separating them requires special diffraction gratings. HZB produces gratings of the highest quality for light sources around the world. The production of just one grating takes several months, and every single one is made to measure. The material used is a highly polished single crystalline silicon block. A thin layer of gold is first vapour-deposited onto the block in a cleanroom. Then, nonstop for days and nights on end, around 100 000 of the finest lines are fully automatically engraved into the gold mask. After quality control, the silicon block is bombarded with ions that etch ultrafine grooves into the silicon surface.

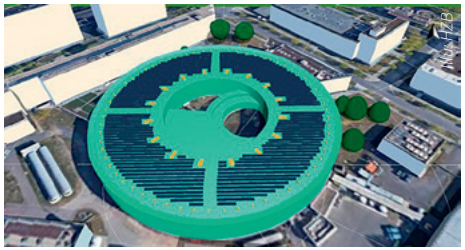
These diffraction gratings are used in instruments at BESSY II. The team also supplies them to nearly all soft light sources in Europe. The Swedish light source MAX IV, alone, has 19 gratings produced by HZB. Enquiries have also been received from institutions in Asia, and orders have already been placed by American light sources: “They have heard how good the quality is that we deliver,” says Marcus Loergen, who heads the department. (arö)

BESSY II is becoming more sustainable

BESSY II delivers bright light for research. Generating this light requires a lot of energy. It consumes a whopping 30 gigawatt hours per year, roughly the equivalent of 7 500 four-person households. Since 2020, HZB has used exclusively green electricity from Scandinavia to run BESSY II. Now the experts are working to improve its energy efficiency. One idea is about to be put into practice.

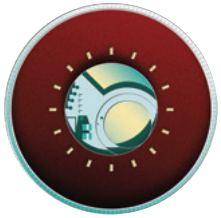
Electrons race around in a circle at near light speed, vacuum pumps hum away in the experimental hall, and beamlines are heated while other components are cooled to keep them working reliably. All of this causes BESSY II to heat up considerably. So far, the waste heat has simply been lost. However, a feasibility study from 2022 demonstrated that this heat can be put to very good use. Head of Facility Management Robert Müller explains: "The waste heat from BESSY II delivers a temperature of up to 32 degrees Celsius, which we can use to heat our buildings. All this time, we have been wasting that energy."

Heating two new buildings on the HZB campus requires a supply temperature of at least 45 to 50 degrees Celsius. The idea is to use heat pumps to bring the water that has been preheated by BESSY II up to the higher temperature required. The conversion will already start this year. It will cost a good two million euros, which will be provided by the Federal Ministry of Research. Next, the plan is to heat the Technikum and the new CatLab building in Berlin-Adlershof. "From these model projects, we are gaining valuable experience, which will benefit us later in other plans," says Robert Müller. There is no need to worry about cold heaters during the times when BESSY II is idle: the buildings will also be connected to the district heating.



There is plenty of space for PV-modules on the roof of the experimental hall.

In addition to heat recovery, there is another concept that many have long considered: the roof of the experimental hall would be ideal for installing PV-modules. For this to be possible, however, the hall roof would have to be renovated for greater energy efficiency and made structurally sound, which is overdue after 25 years anyway. The idea has special appeal, since HZB counts among the top establishments in the world for photovoltaics



GREEN ELECTRICITY
Since 2020, HZB powers BESSY II with green electricity from Scandinavia.

HEAT RECOVERY
So far, the waste heat generated by the operation of BESSY II goes unused. That will soon change.

PHOTOVOLTAICS
HZB has plans to produce its own solar power for operating BESSY II.

research. So what would be more obvious than getting some of its own energy from the sun? From a technical point of view, the plans could be easily realised, Robert Müller asserts, but funding is still an open issue.

The interior of BESSY II is another area where much can be done to reduce the energy requirements. It is currently being hotly debated in the accelerator community what components should be converted first. The two largest consumers of an accelerator are the magnet system and the high frequency systems required for particle acceleration. The electromagnets used to date could in future be largely replaced by permanent magnets, which would consume no electricity. There is already collaboration with industry in an EU-funded research project to increase the efficiency of the existing high-frequency systems. Such approaches are, of course, also making their way into the plans of BESSY III.

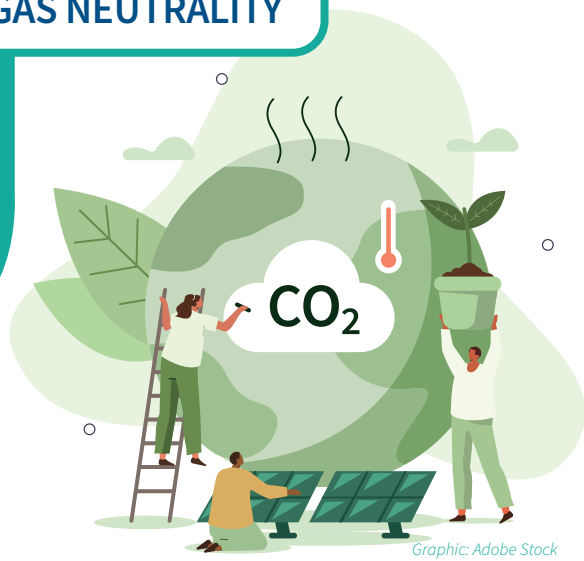
HZB is focusing on its CO_2 emissions not only at BESSY II. In 2023, HZB was the first research institution in the Helmholtz Association to record its emissions in a greenhouse gas report pursuant to the Greenhouse Gas Protocol, and is currently having this externally certified. There is concrete planning for the implementation of many measures. This shows that we are not only researching climate-friendly technologies, but are putting them into practice ourselves. Because the clock is ticking: HZB wants to be greenhouse gas neutral by 2035 – and every step in the right direction counts.

■ BY SILVIA ZERBE

HZB

2035

GREENHOUSE GAS NEUTRALITY



Graphic: Adobe Stock

COMPONENTS

Work is already being done on the efficiency of the high frequency systems. The magnet systems are also in HZB's sights.

GREENHOUSE GAS REPORT

HZB is having its greenhouse gas emissions, including those of BESSY II, recorded and externally certified.

Picture: Silvia Steinbach

Highlights from 25 years of research

For a quarter of a century, BESSY II has been delivering bright light for research. Guest experimenters come from all over the world to study their samples at the light source.

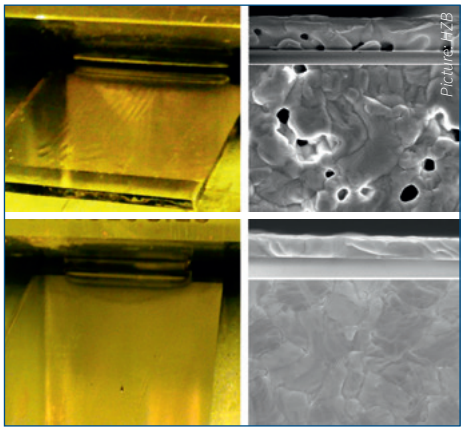
Many high-ranking papers have been published during these 25 years. The direction of research at BESSY II has also developed over this time.

Today, BESSY II has an excellent reputation for its diverse in-situ and in-operando capabilities. They are ideal for studying materials for energy conversion and energy storage, such as solar cells and batteries, as well as quantum materials for energy-efficient computing technologies. This goes hand in hand with the fact that HZB has developed into a leading centre for energy and materials research.

Measurements for deciphering protein structures are also in high demand. The light source BESSY II sets the hearts of researchers racing in many disciplines. Here they can perform unique experiments and obtain amazing results, as our scientific highlights show. (arö)

2023

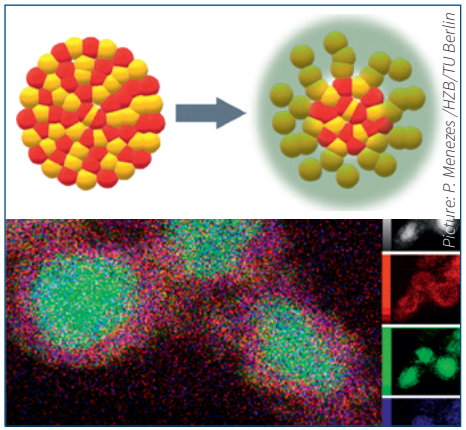
PEROVSKITE SOLAR CELLS FOR INDUSTRY



Solar cells made from metal halide perovskites achieve high efficiencies and can be produced from liquid inks with little energy input. An HZB group at BESSY II showed how important the composition of the precursor inks is. Their solar cells were field-tested for one year outdoors and have been scaled up to minimodule size.

2022

NICKEL SILICIDE SHINES AS A CATALYST

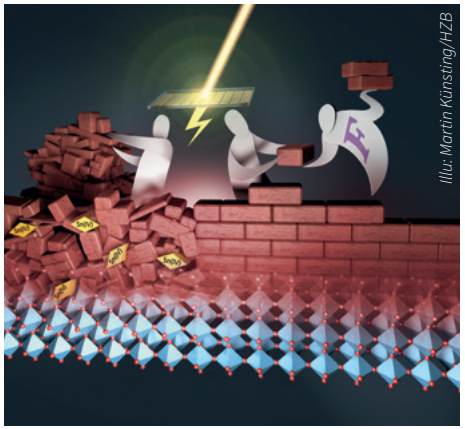


Energy from the wind or sun can be stored as chemical energy in hydrogen. A prerequisite for this is affordable catalysts. Nanostructured nickel silicide can significantly boost the efficiency of the oxygen evolution reaction at the anode, as demonstrated by measurements at BESSY II.

Today, BESSY II is in particular demand because of the wide range of investigation possibilities in energy research.

2021

LEAD-FREE PEROVSKITE SOLAR CELLS



Tin halide perovskites are considered the best alternatives to lead-based analogues. Yet, they are less efficient and less stable. An HZB team analysed the chemical processes in the perovskite precursor solution and its fluoride chemistry. By combining measurement methods at BESSY II using nuclear magnetic resonance, they showed that fluoride prevents the oxidation of tin. This increases the quality of the semiconductor layer.

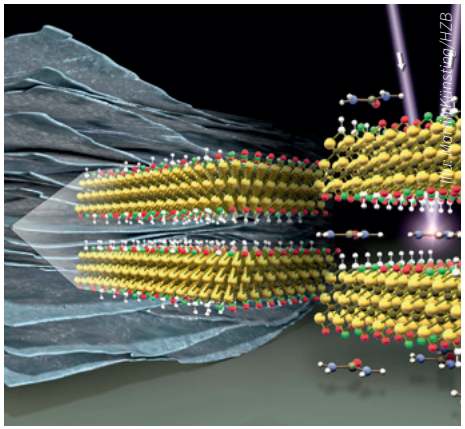
2021

METALLIC WATER DETECTED

Under normal conditions, pure water is an almost perfect insulator. Water only develops metallic properties under extreme pressure. An international collaboration used a completely different approach to produce metallic water and documented the phase transition at BESSY II.

2020

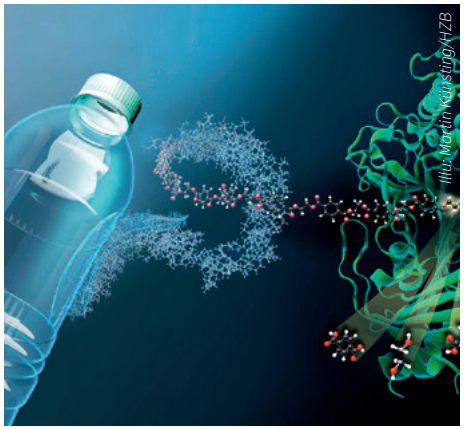
NEW MATERIALS FOR ENERGY STORAGE



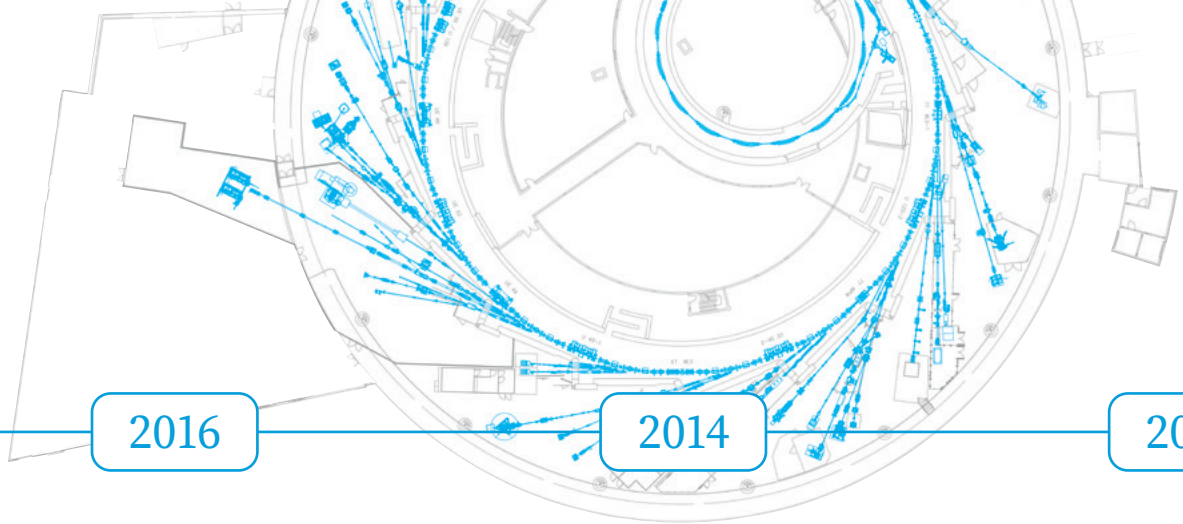
MXenes can store electrical energy very quickly. At BESSY II, researchers discovered that sandwiching urea molecules between the MXene layers can increase the capacity of such pseudocapacitors by more than 50 percent.

2019

BETTER WAYS TO RECYCLE PLASTIC WASTE

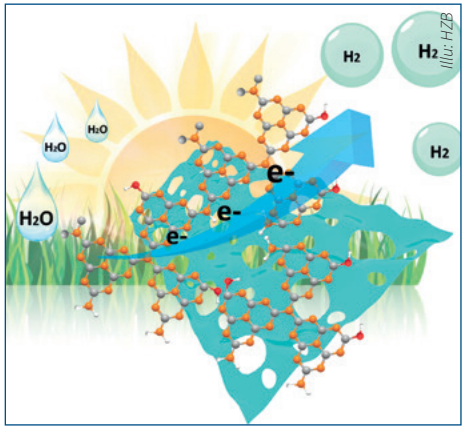


Research teams deciphered the structure of an important enzyme (“MHETase”) at BESSY II. Together with a second enzyme, PETase, this enzyme is able to break down PET plastic into its basic building blocks. This could allow truly sustainable recycling.



2018

EFFICIENT METAL-FREE PHOTOCATALYSTS

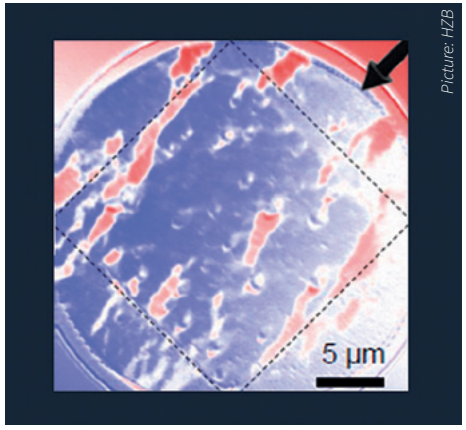


Illu: HZB

Polymeric carbon nitrides can be used as catalysts for producing solar hydrogen. Using the light from BESSY II, researchers discovered the role played by nanostructures in the process. They increased the efficiency of these inexpensive, metal-free materials by a factor of eleven.

2016

NEW DATA STORAGE: MAGNETIC PATTERN DISCOVERED

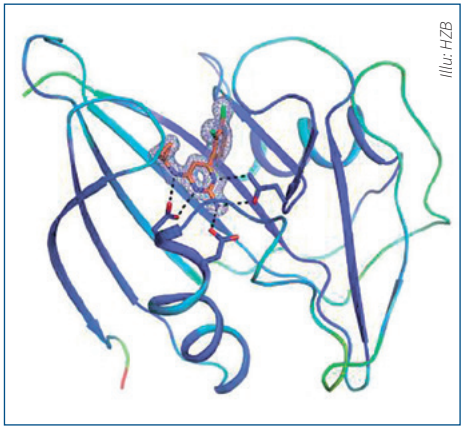


Picture: HZB

Researchers found a way to produce exotic magnetic patterns such as monopoles and vortexes in thin magnetic films. At BESSY II, they mapped the magnetic domains inside an iron-nickel film. The material is considered a candidate for future magnetic storage media.

2014

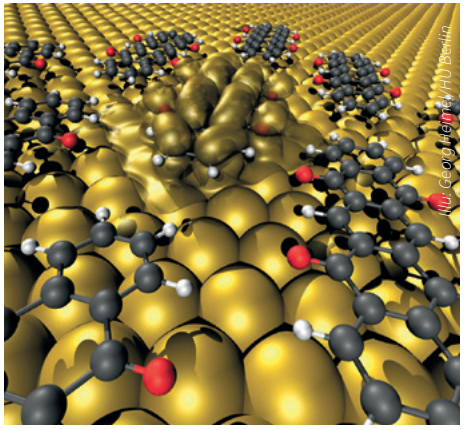
NEW CONCEPT FOR CANCER TREATMENT


Illu: HZB

A Swedish team discovered a new approach to treating cancer. They blocked the enzyme MTH1, which cancer cells need to survive but normal cells don't. They solved the enzyme structure at BESSY II and obtained valuable information for developing active substances to inhibit it.

2013

ORGANIC ELECTRONICS

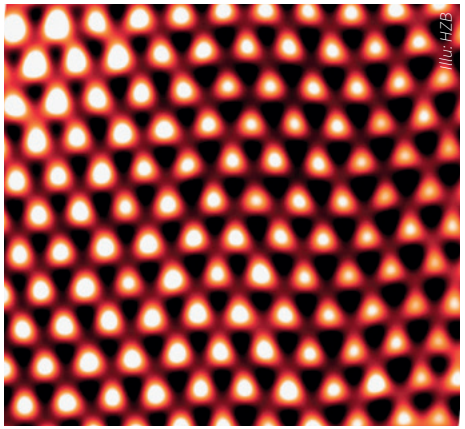

Illu: Georg Heimel / HU Berlin

Organic electronics are used in displays and allow flexible light-emitting films and solar cells. Various organic molecules are used to join metal contacts onto the active organic layer. At BESSY II, a team discovered how the contact layers can be targetedly improved.

»BESSY II has delivered 25 years of spectacular results and has always been a magnet for international scientific exchange.« **Bernd Rech**

2012

GRAPHENE ON NICKEL



Graphene consists of carbon atoms connected in a single layer to form a flat hexagonal lattice. Graphene is also highly conductive. If graphene is deposited onto nickel, it develops distortions in the lattice. The electrons of graphene behave more like light and less like particles, studies at BESSY II have shown. This mechanism is of great interest for practical applications.

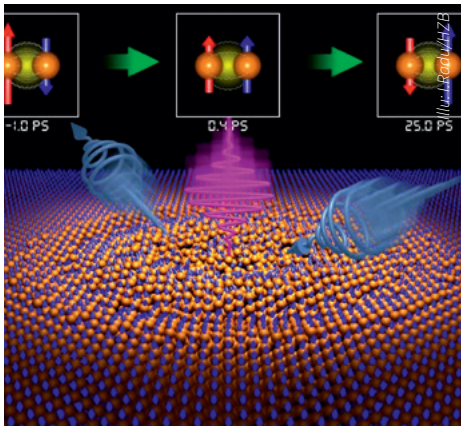
2012

FUNGI ARE WEATHER MAKERS

In rainforests, organic vapours and salts are responsible for the formation of fog and clouds. A team at BESSY II studied aerosol particles from the Brazilian rainforest. They showed that these particles contain potassium salts, which fungi and plants exhale, and thus appear to influence the formation of clouds.

2011

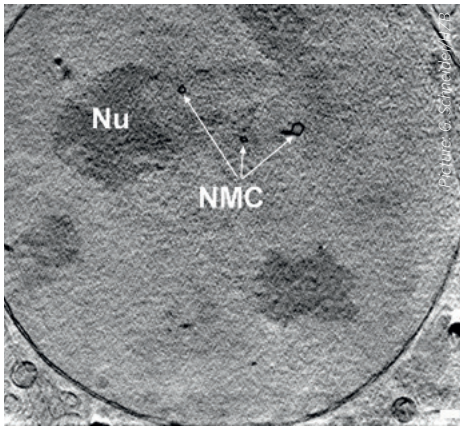
ULTRA-FAST MAGNETIC REVERSAL



At BESSY II, a team observed a new effect in an alloy of gadolinium, iron and cobalt. Using ultrafast light pulses, they showed that the magnetic alignment of the iron atoms reverses five times faster than that of gadolinium. This results in strong short-term magnetisation, and could speed up data processing.

2010

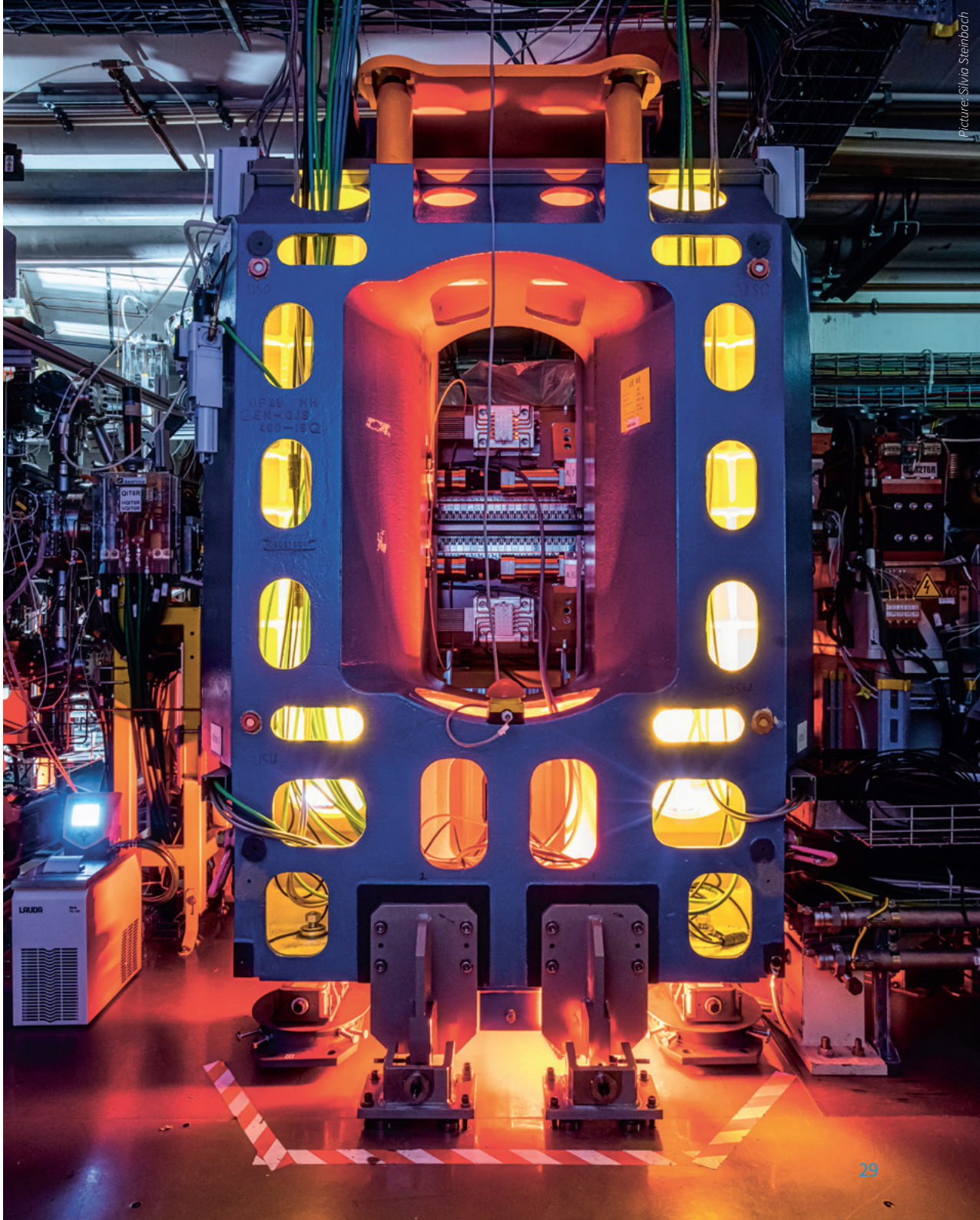
DEEP INSIGHT INTO THE DETAILS OF A CELL



With an X-ray microscope newly developed at HZB, individual cells of mammals can be non-destructively imaged in high-resolution 3D – even in their natural environment. This picture shows the cancer cell of a mouse with details such as cell nucleus and membrane channels.

11 000 +

More than 11 000 publications can be traced back to experiments performed at BESSY II. That is a phenomenal output. So, it is in the nature of things that many outstanding results could not be included in the selection of research highlights here, despite each of them having advanced their scientific fields. Rather, this small excerpt is intended more to demonstrate just how diverse the research is at BESSY II, and how it is helping to answer many societally relevant questions.



Picture: Silvia Steinbach

Picture: Felix Lehr

BRIGHTER, FASTER AND STRONGER

Why we need a fourth generation light source in Berlin-Adlershof

BESSY III will be the new state of the art accelerator facility operated by HZB in the science campus Berlin-Adlershof. After several decades of operation, BESSY II light source will gracefully step aside to make way for BESSY III. To paraphrase Daft Punk, the follow up light source will be "Brighter, Better, Faster, Stronger". But what does that really mean? And why is the upgrade necessary?

Many challenges of the 21st century call for novel and increasingly complex material solutions. These challenges range from increasing renewable energy production and storage, to more efficient and sustainable computing solutions. Investigating such complex materials at third generation light sources such as BESSY II is often limited. On the other hand, BESSY III will be a fourth generation light source that will produce extremely bright X-rays that can probe variations in complex materials on miniscule scale lengths. By enabling in-depth study of novel materials, BESSY III will pave the way for three exciting research areas: Energy, Quantum Information Technology and Life Sciences.

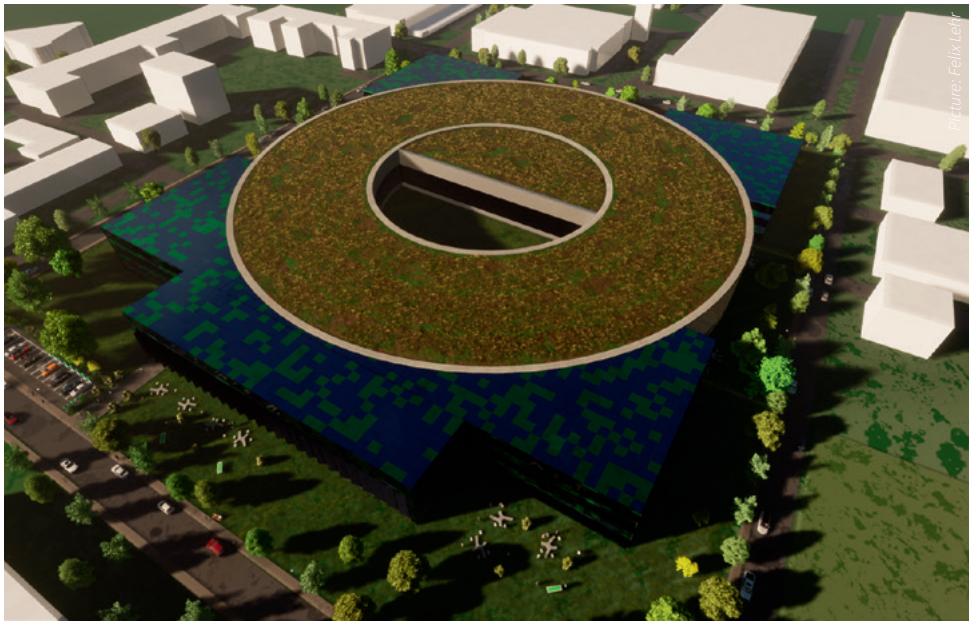
> So that Germany can become climate-neutral by 2045, it will require new technologies. BESSY III will play a major role in this.

To enable Germany's goal of climate neutrality by 2045, and move towards a sustainable energy economy, ground breaking new technologies are urgently required. Advances in solar cell efficiencies and battery technology beyond the current state of the art will be needed by exploring novel and increasingly complex multilayered materials. Optimisation of these devices will be possible at facilities like BESSY III which enable access to fast analytical tools that shine light on the processes occurring on the atomic scale in these materials during operation.

Quantum computing is another area that would hugely benefit from investigation on very small-scale lengths. Quantum computers have the potential to operate faster than even state of the art "modern" computers available today, thus minimizing energy consumption. The devices that are used in quantum computers are not so well understood because the relevant processes in the materials typically occur on even smaller than atomic scales, they occur on quantum scales! X-ray based techniques available at BESSY III will enable insight into the underlying

phenomena at work in such devices, potentially making quantum computers more practical and applicable to our day to day lives. Complex structures are by no means confined to man-made materials. Understanding the complex processes of the human body is an ongoing challenge, that holds the key to combatting viral infections and many diseases including cancer and dementia. Unlike other imaging methods that alter the specimen under study, light sources like BESSY III allows the study of specimens in close to their natural state (e.g. by cryo-preserving tissue samples). Using the Swiss army knife of imaging methods that will be available at BESSY III, it is possible to obtain a deeper understanding on how molecules responsible for diseases function. This, in turn, would lead to the development of drugs and vaccines. As the COVID-pandemic demonstrated, speed is of the essence when it comes to developing treatments for viruses, which may become more prevalent in the future.

Facades with photovoltaic elements: the sustainability of the building and accelerator components is planned in from the outset.



BESSY III WILL MAKE NEW LEAPS

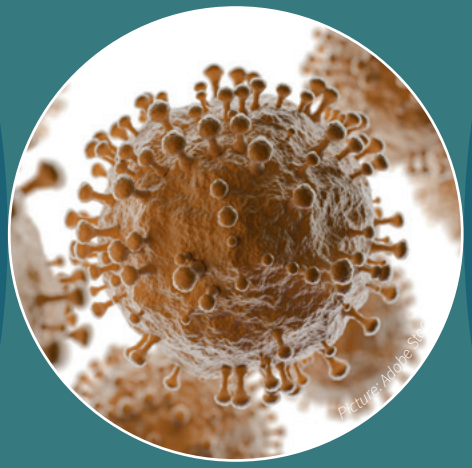
BESSY III will bring unprecedented new discoveries, even beyond the leaps in energy, quantum computing and life sciences discussed here. Many scientific disciplines and economic industries alike will benefit from these discoveries. A new soft X-ray source in Berlin-Adlershof – accompanied by many top establishements in research – thus secures innovations and jobs in Germany. So when can we expect the new facility to be ready? BESSY III is currently in the design phase, construction is planned to begin in 2029, and completion and operation of the facility is forecasted for 2035.

SONAL MISTRY
Postdoc in
accelerator physics

Curious objects at BESSY II

2020

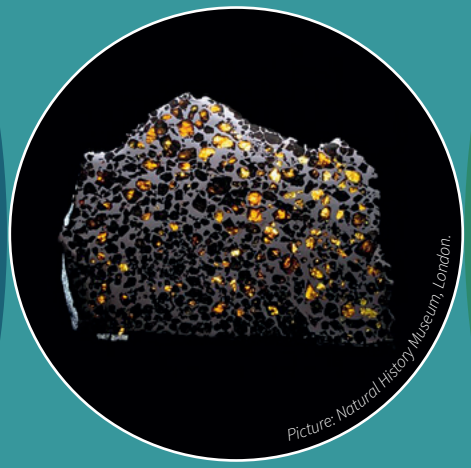
THE CORONAVIRUS



The three-dimensional architecture of an important surface enzyme of SARS-CoV-2 was decoded at BESSY II. Knowledge of this structure helps in the search for active agents that could prevent the replication of these viruses.

2015

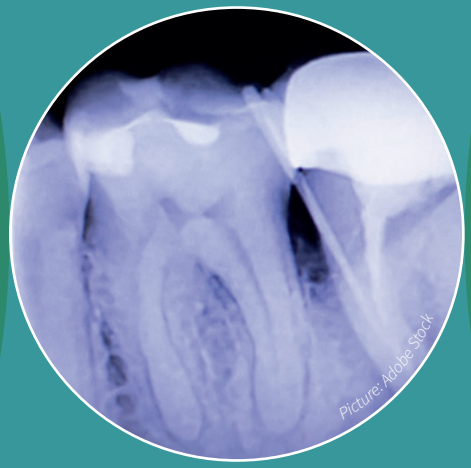
THE PALLASITE METEORITE



A team studied samples from a pallasite meteorite at BESSY II. They identified tiny particles that had aligned themselves magnetically during the early stages of the solar system. The meteorite had thus saved data, so to speak, from millions of years ago like a hard drive.

2014

X-RAYING THE ROOT OF A TOOTH



At BESSY II, researchers studied whether drilling out the roots of teeth can cause fine fractures. The good news is: the kind of drilling performed presents no particular risk. Using micro-computed tomography, they were able to measure details at the boundary between the filling and dental root as well as microcracks in the tooth substance with great precision.

2012

THE VIKING TREASURE FROM OSEBERG

The Museum of Cultural History in Oslo studied valuable objects from the Viking Age at BESSY II. The artefacts are from a Viking grave found in 1904 at Oseberg near the Oslo fjords. The experts obtained this new knowledge using nondestructive methods at BESSY II, with the aim of preventing the degradation of these works of art.

2004

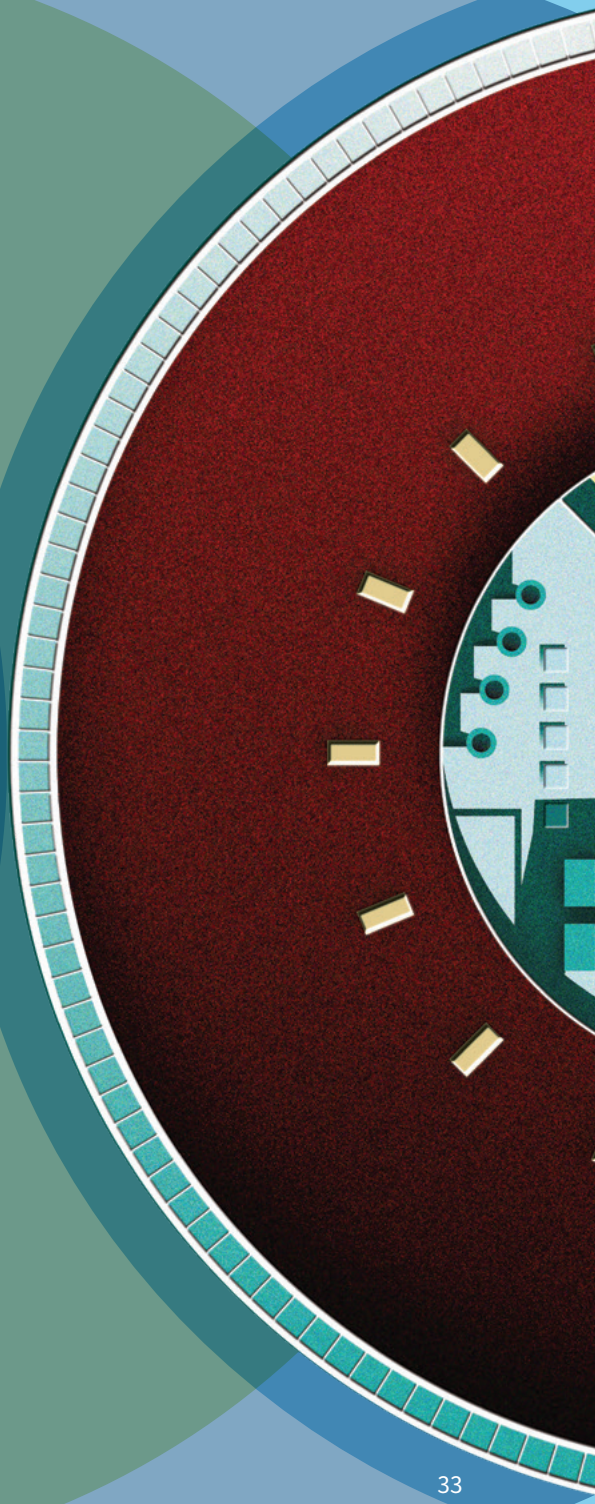
THE GOLD TREASURE FROM HIDDENSEE

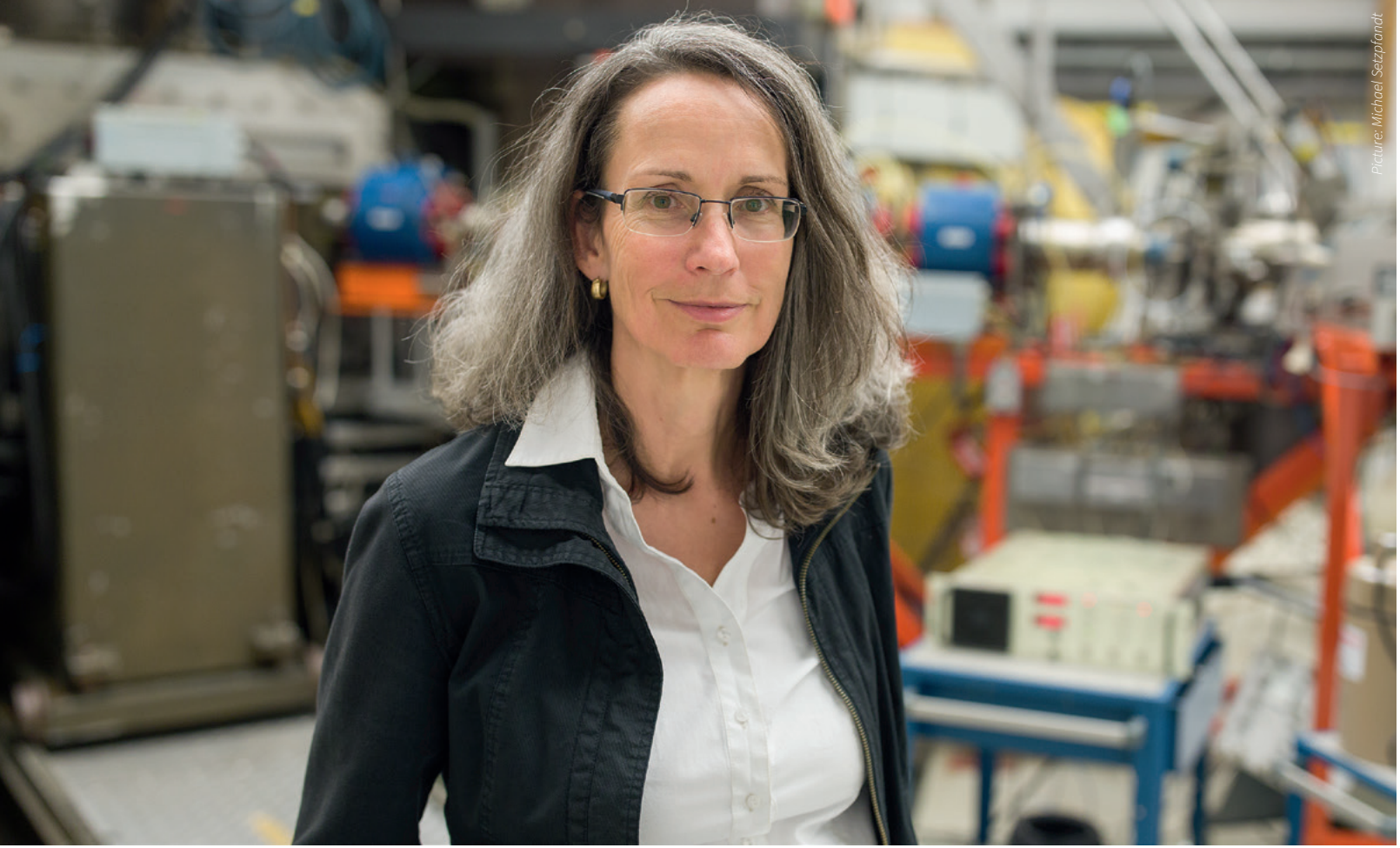
Art experts used BESSY II to study golden jewellery dating back to the Vikings, which had swept ashore on the island Hiddensee. The results provided insights into manufacturing techniques and solder metals.

2003

THE NEBRA SKY DISK

A most spectacular find from the year 1999 was the Nebra Sky Disk: a beautiful monument from the early Bronze Age. Its various gold alloys were studied at BESSY II. The findings allowed inferences to be made about trade routes and about changes in belief systems some 4000 years ago.





Picture: Michael Setzpfandt

INTERVIEW WITH ANDREA DENKER

25 years of proton therapy for eye tumours

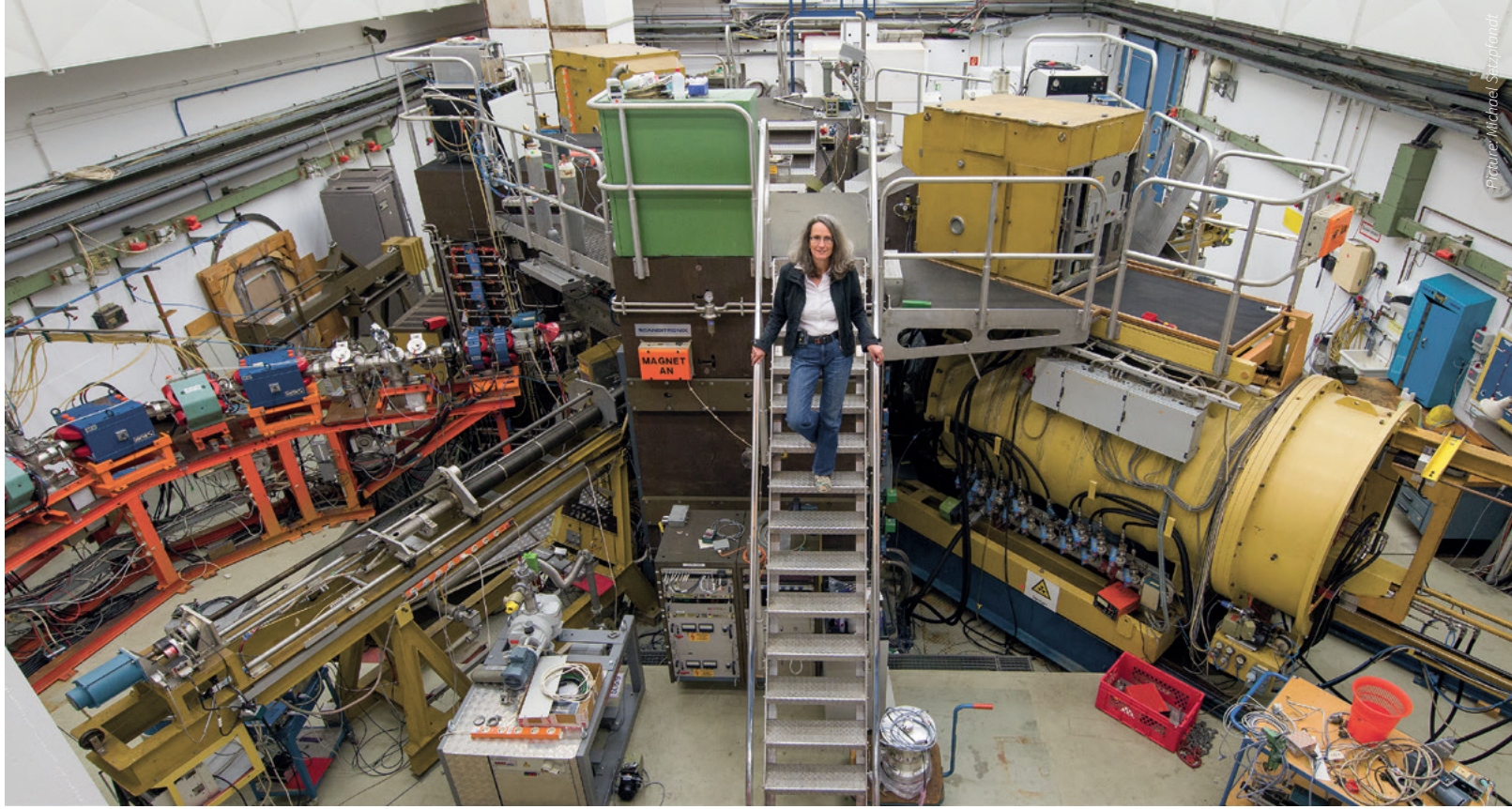
Another HZB accelerator facility celebrates its 25th anniversary this year: the proton accelerator in Berlin-Wannsee. Many eye tumour patients benefit from the eye-saving treatment here.

The particle accelerator here in Wannsee was originally used for entirely different purposes, such as investigating materials. How did it come about that this accelerator was converted for treating eye tumours?

Andrea Denker: Michael Foerster brought the idea to Berlin after a stay in the United States in 1991. By the time I started at the Hahn-Meitner-Institut, as it was called in 1995, this idea had already taken concrete shape, and eye tumour therapy was in its startup phase. The aim was to optimise the accelerator for the extreme demands of therapy on humans. It was very challenging because, in this case, there was absolutely no room for error.

When did you have your first patients?

In the middle of 1998. In the first therapy week, we had only a single patient. There were so many things we still had to carefully sort out. By comparison: today, we treat up to 25 patients per therapy week. That means



Picture: Michael Setzpfandt

Andrea Denker, Head of Proton Therapy at HZB, stands in the centre of the cyclotron: this machine produces a beam that can be used to destroy eye tumours.

we accommodate nearly the entire demand for the treatment of these rare eye tumour diseases. Germany now has a second facility that offers this type of therapy, in Essen. But ours can offer higher precision.

Are there patients who remain particularly strongly in memory?

Every patient is special, and we always try our hardest to accommodate everyone. For example, we have developed a suitable seat for small children. But we also once had a patient who suffered from curvature of the spine. For this case, our central workshop just went ahead and built a seat that this patient could sit in without pain.

What experiences are you particularly fond of remembering?

There are certain experiences where I felt a tremendous sense of solidarity. Once, we had a power failure during the therapy week and everyone was scrambling, around the clock, to make sure the patients could still be treated.

Or another example is in 2021 where, at around 5 pm, our power was out for three hours. That is a catastrophe because the accelerator was completely out of commission, and the vacuum was getting weaker. Some of us stayed overnight, I ordered pizza, and during the night we managed to get the accelerator up and running again. And so, on the next day, we were able to continue, with the patients receiving their treatment with only an hour's delay. The treatment is always the most important thing.

How will eye tumour therapy develop in the future?

We are pursuing new approaches to make the treatment even more gentle in the future. But we also have long-term plans; for example, we are working on a concept for a new ion accelerator for helium ions. First of all, to continue doing eye tumour therapy, of course. But, in addition to that, we also want to offer permanent possibilities to research materials – in particular radiation hardness tests for materials that will be used in space.

Interviewed by Antonia Rötger.

BESSY II – serving coffee and fresh photons since 1998

B... for Bunnies

"Before Adlershof became so built up, there were many more rabbits than now. One time, before our very eyes, a rabbit gave birth to five kits beside the wall of the BESSY II hall right next to the main entrance. We helped the bunny in fending off the crows but, two days later, all the kits were gone. We hope the bunny had found a better place to put her young ones."
Peer from BESSY II Reception

E... for amnEsia

"A long time ago, we were sitting with four colleagues over coffee and we somehow got it into our heads to play a prank. We took off the first row of keys on the keyboard of one of our colleagues and stuck them back on out of order. You should have heard us laugh! On Monday morning, the colleague came into the office and tried desperately to log in. He couldn't. But the worst thing was, our memories were playing tricks on us, too, because none of us could even remember having pulled the prank. So there we all were, trying everything to figure out what was wrong with the computer. Until a long time later, the penny dropped, and we told our colleague everything! Those who dig a pit for others..." **Ingo Müller**

S... for Sahne

"Aber bitte mit Sahne" – inspired by the hit song by Udo Jürgens, BESSY II decided to celebrate its 10th birthday with a cream cake. But the consequences were terrible. As many guests can testify, the indulgence led to an awful case of diarrhoea and vomiting. And so, to this day, the philosophy goes: we love celebrating birthdays – but, please, without the cream cake!

S... for Sound

In addition to all the aluminium foil and cables, those visiting BESSY II for the first time are also struck by the characteristic sound produced by the many vacuum pumps in the experimental hall. This soundscape inspired artist Gerrit K. Sharma to create acoustic sound sculptures, which premiered in 2017. A journalist from Deutschlandfunk also captured the sound of BESSY II for a radio feature.

Picture: Florentine Krawatzek

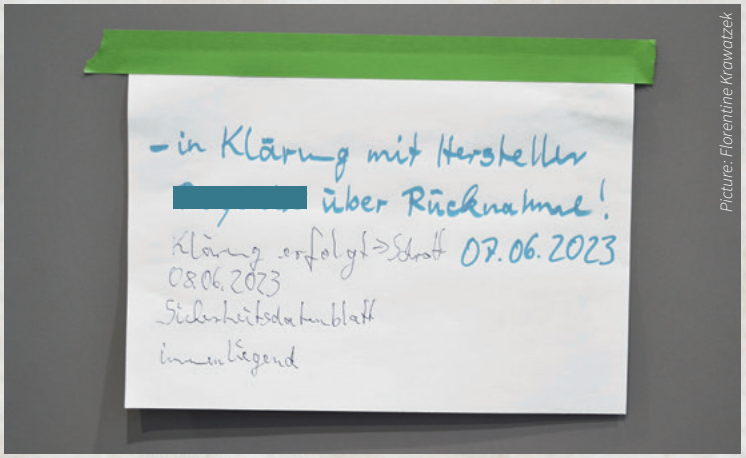
BESSY II in diner style: Just like in a cosy bar, all the exotic wishes of guests are fulfilled at BESSY II. Movie on YouTube

Y... for Yvonne

"For the letter Y, I immediately think of Yvonne. Yvonne was the wife of a former colleague I worked with in the early two thousands. She was extroverted, empathetic and cheerful, and seemed to be completely true to herself. I had just started my postdoc studies at the time, and was trying to find my personal style as a university teacher. When we talked, Yvonne often had a different view of things than the one that was typical for physics circles, and I always found that to be very stimulating and helpful. These conversations surely had a big influence on my leadership style, and are one of the many ways in which the BESSY cosmos has been formative for me."
Atoosa Meseck

Plenty of creativity at the ring

Total clarity, communication at its best



Picture: Florentine Krawotzek

Found in the experimental hall

How is your battery on Friday...

Picture: Florentine Krawotzek

...also drained? Get your indicator here.

Happy Birthday, BESSY II

Picture: Silvia Zerbe

Picture: Florentine Krawotzek

At your own risk

Cabinet # 030

Picture: F. Krawotzek

Hells Bells?

Picture: Silvia Steinbach


25
www.helmholtz-berlin.de