DESY inFORM.

03/2011
Newsletter of the
Research Centre DESY

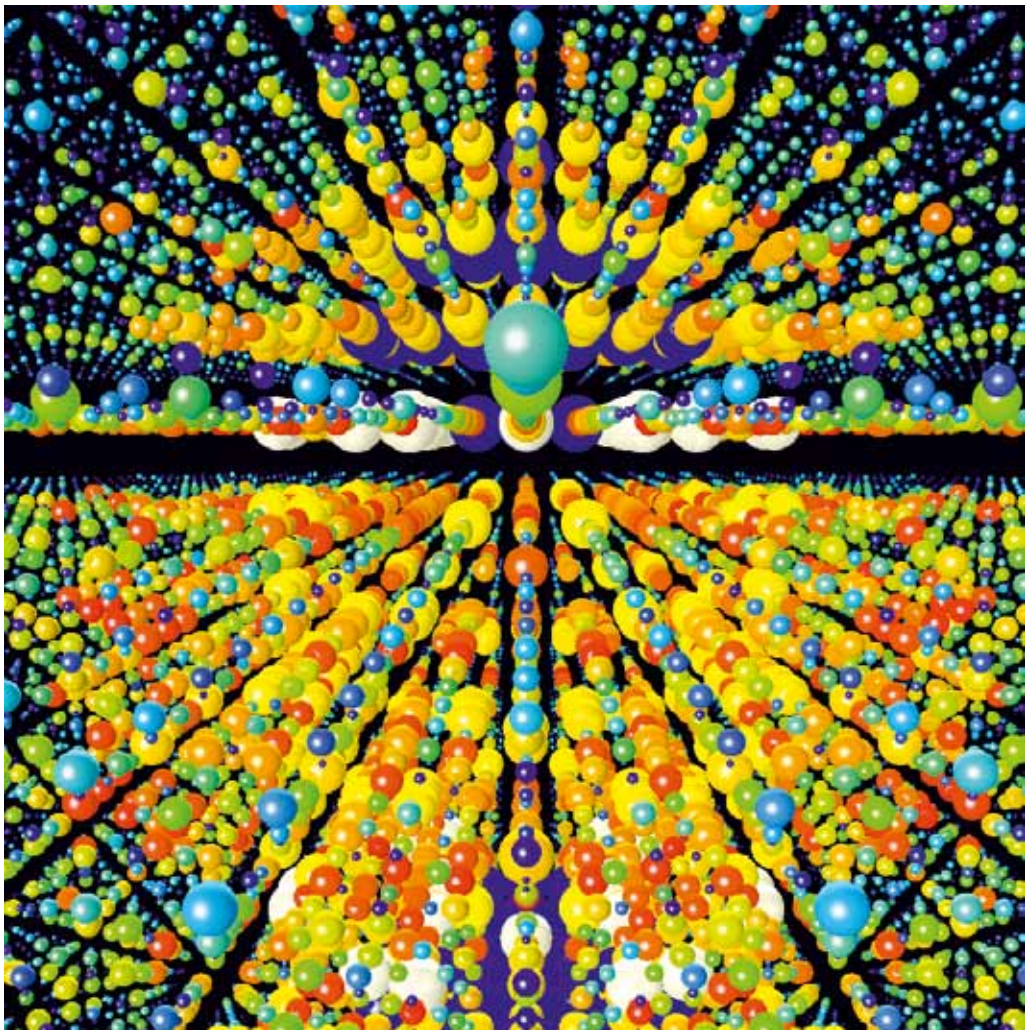
Discovering a new world

First X-ray laser images of proteins and viruses at LCLS

It has been a dream of researchers for years: image biological structures at high resolution using incredibly intense X-ray laser pulses. It should be possible to make precise measurements of the molecular structure of extremely small samples with X-ray pulses; but, in the usual methods, the samples are damaged before their structure is identified. However, new free-electron lasers generate ultra-short light pulses which are a billion times brighter than conventional light sources. With these pulses it is possible to form images before the sample is damaged. Now, a collaboration led by Henry Chapman of the Center for Free-Electron Laser Science CFEL at DESY, has proven this at the free-electron laser LCLS (Linac Coherent Light Source) at SLAC.

The group's results, published in *Nature* in February, are a first and decisive step to make visible molecular structures of proteins and to determine the structure of viruses by using single virus particles or nanocrystals of proteins. This avoids laborious crystallisation processes that are traditionally needed to determine a detailed structure.

"These achievements are a culmination of many years of effort that began with prototype experiments at DESY's FLASH facility, the free-electron laser in Hamburg," said Henry Chapman. "We were surprised and thrilled as to how well the experiments worked."



Three-dimensional rendering of X-ray diffraction data obtained from over 15 000 single nanocrystal diffraction snapshots recorded at the LCLS. Each nanocrystal was destroyed by the intense X-ray pulse, but not before information about its structure was revealed.

The 3D structures of proteins and viruses, the so called diffraction pattern, are conventionally recorded by a method called X-ray crystallography. However, large exquisite crystals are needed to get strong patterns before radiation

CONTINUED ON PAGE 2

1000 times thinner than hair

PETRA III has generated its thinnest light beam yet. Already at the end of user run 2010, a team of scientists from KIT, Gent University, TU Dresden and DESY managed to create a light spot at beamline P06 smaller than 100 nanometres at the sample – 1000 times thinner than a human hair. This makes the X-ray fluorescence measuring station an ideal tool to determine for example the exact distribution of chemical elements in biological samples, or the distribution of extremely small crystal domains in minerals. For this year, the scientists promise another reduction of the X-ray beam to 30 nanometres.

DIRECTOR'S CORNER

Dear colleagues,

the past weeks were full of highlights from quite different fields: a new basis for the centre's future strategy development and very concrete great moments for science.

On 8 February, we and the University of Hamburg jointly founded PIER – the "Partnership for Innovation, Education and Research." PIER lends a structure to our well-established partnership, providing better possibilities for common research activities in the future.

A first good example is the fundraising of Joachim Herz PhD scholarships. We are now in the process of establishing the PIER office which, apart from graduate scholarships, will take care of the PIER ideas fund and other projects.

Through a paper published in *Nature*, a collaboration led by Henry Chapman (CFEL) proved for the first time at the LCLS at SLAC how to image proteins and viruses with ultra-short light pulses before they are damaged by these laser pulses. These results are a decisive step to making visible the dynamics of molecular processes.

From 2015 on, many experiments at the European XFEL will focus on these questions. Another great success for us at DESY is the publication of Franz Tavella and his team in *Nature Photonics* about the measurement of the arrival time of X-ray pulses with an accuracy of less than ten femtoseconds.

It both cases, it is clear that good collaborations are essential for our work, including the fact that DESY is in national and international demand as a collaboration partner.

Yours,

Helmut Dosch

damage sets in. The free-electron laser LCLS produces bright X-ray pulses that are so intense that any sample placed in their path is vaporised into plasma – but only after the brief X-ray pulse passes the object at only 100 femtoseconds. The diffraction pattern obtained thus carries the information about the undamaged object, allowing the viewing of single virus particles.

The experiments published in Nature made use of the so called CAMP chamber and pnCCD detector system, designed and built by the Max Planck Advanced Study Group at CFEL, a cooperation of eight Max Planck Institutes. The target objects are fed into the X-ray beam in an aerosol beam or a gas-focussed liquid jet. With this test setup, the scientists collected 1800 individual patterns every minute. By the time the next pulse arrives, at a rate of 30 per second, a new particle is delivered to replace the vaporised one before it. The high-speed X-ray detectors recorded and digitised millions of patterns over the course of several days.

In their experiments, the scientists imaged the so-called Photosystem I protein complex and the mimivirus. Photosystem I is a decisive component to convert sunlight into energy via photosynthesis. The Photosystem I nanocrystals were an ideal sample for the proof-of-principle experiments. The ultimate application of this technique is to record patterns from single molecules without the need for crystallisation. This goal requires further development to focus the X-ray pulses to smaller spots, giving even higher intensities.

The collaboration carried out yet another proof-of-principle experiment on imaging single copies of the giant mimivirus, the largest known virus which infects amoebas. The experiments show the feasibility of eschewing crystallinity altogether. Thousands of patterns of single viruses were recorded, and each single image reconstructed. This new way of imaging avoids having to freeze, slice or chemically label the structure, and could be extended to whole living cells.

PIER sets sails

Since its foundation more than 50 years ago, DESY has closely collaborated with the University of Hamburg. On 8 February, this cooperation was put on a firm (and maritime-sounding) basis. With "PIER – Partnership for Innovation, Education and Research", a strategic partnership was launched which will be a point of crystallisation for excellent research in Northern Germany. In the Hamburg City Hall, in the presence of Senator for Science Herlind Gundelach, University President Dieter Lenzen and DESY Director Helmut Dosch signed the new partnership agreement. In the press conference that followed, they presented PIER to the journalists. Afterwards, there was a parliamentary evening in Berlin. In Hamburg's federal state office, the partnership was introduced to Berlin politicians in a lively debate. One of the dialogue partners on the podium was Petra Herz, Chairwoman of the Joachim Herz foundation that supports PIER with more than half a million Euros for a PhD scholarship programme.

PIER will intensify cooperation in four research fields: particle and astroparticle physics, nanosciences, photon science, and infection and structural biology. Therefore there will be a PIER office on the DESY campus in Bahrenfeld, coordinating the collaboration in a total of six fields of action. There are plans for joint appointment procedures for professors, and with the help of the PIER ideas fund, a start-up funding helps to realise brilliant project proposals. Additional points of action are a research-oriented programme for young scientists and the lively exchange of ideas with commercial enterprises. *(tz)*

INFO

www.pier-campus.de

The photo shows the visible painting and – overlapping at left – the picture behind it. The antimony distribution is shown in black and white. A very similar lead distribution suggests that the young woman on the original picture was blond.

Tracing the old masters

X-ray sources move works of art into a new light

With old paintings you sometimes do not know for sure who the artist was. One example for this unceratinty "Pauline in a white dress", which cannot be attributed to the artist Phillip Otto Runge with certainty. The picture shows a young woman with an elegant hairdo in front of a landscape with trees, dreamily looking to the side. The painting is about 200 years old.

The art collector who owns this picture wanted to know whether it was a genuine Runge painting. Pictures existing beneath the surface might give evidence. Since canvas was expensive in former times and most painters did not have much money, they often painted over unsuccessful or unfinished pictures.

To make visible the underlying picture without destroying the surface, the painting was examined at DESY using a special method, X-ray fluorescence analysis. The painting is being scanned spot by spot with an X-ray beam to detect which elements are hidden under the surface, since different chemical elements emit fluorescent light with a characteristic energy when induced by X-ray radiation. This enables scientists to identify the elements and deduce the colours that were used. Subsequently, with a computer, the detected colours can be assembled into a picture again.

In the painting underneath "Pauline", one can see the same woman, but wearing loose hair and an evening dress. She has a less serious expression, but her face looks much the same.

"Comparing it with known drawings, we could bring the picture in closer connection to Runge," said Matthias Alfeld from the University of Antwerpen. Runge is known to have painted his sister with similarly loose hair. Now it is assumed that the "Pauline" picture portrays his wife Pauline.

Experts already used this method to investigate paintings of Vincent van Gogh and Rembrandt, finding arguments for their authenticity, since the paintings that were made visible were mentioned in writings or fitted into the painter's epoch.

INFO

This article was written by Lilian Grotelüschen during an internship for pupils at DESY.

End of project phase

The PETRA III project phase was concluded end of 2010. This means that the conversion phase has officially finished which officially makes PETRA III a completed DESY facility. A lot of research has been done at the beamlines already before completion; for example at beamline P03, which provides users with ultra-intensive beams in the micro- and nanometre range.

March

2 Science Café DESY (http://sciencecafe.desy.de)
Schwarze Löcher sind nicht schwarz – sie leuchten!
Waldemar Tausendfreund, DESY Bistro, 17 h

4 Chorkonzert DESY-Chor
Night and Day – Klänge aus der goldenen Zeit von Musical und Jazz
DESY, Hamburg, canteen, 20 h

7 International Masterclasses (www.physicsmasterclasses.org)
Hands on Particle Physics Masterclasses
DESY, Hamburg

9-11 Workshop (http://indico.desy.de/event/LAP2011)
LATTICE Practices
DESY, Zeuthen

14-17 TERASCALE (www.terascale.de/mc2011)
Monte Carlo School
DESY, Hamburg

15-17 TERASCALE (www.terascale.de/detws2011)
4th Workshop on Detector Development
DESY, Hamburg

20-25 TERASCALE (www.terascale.de/capp2011)
Computer Algebra and Particle Physics 2011
DESY, Zeuthen

21 International Masterclasses (www.physicsmasterclasses.org)
Hands on Particle Physics Masterclasses
HU Berlin

23 Science Café DESY (http://sciencecafe.desy.de)
Was hat regenerative Energie mit Teetrinken zu tun?
Hans-Jörg Eckoldt, DESY Bistro, 17 h

23 Public lecture
Piraterie – Neue Dimension eines alten Phänomens
Eigel Wiese, DESY, Hamburg, auditorium, 19 h

24 **staff assembly**
DESY, Hamburg, auditorium, 9:30 h

April

13 Science Café DESY (http://sciencecafe.desy.de)
Wie man mit Statistik lügt
Frank Lehner, DESY Bistro, 17 h

14 **Girl's Day**
DESY, Hamburg
Zukunftstag für Mädchen und Jungen
DESY, Zeuthen

15 Ein Tag vor Ort (www.eintagvorort.de)
Laborbesichtigungsprogramm für Physik-Studierende
DESY, Zeuthen

27 Public lecture
Röntgenlaser – Neue Erkenntnisse aus der Photonenphysik
Rolf Treusch, DESY, auditorium, 19 h

+++ 29 October: DESY's Open Day and Night of Knowledge (Hamburg) +++

DESY goes green

The protection of the environment has always been an issue at DESY– however, it is of special concern this year. After all Hamburg has been nominated European Green Capital for the year 2011, and DESY is one of Hamburg's environmental partners.

The first event in this context was a meeting at DESY focusing on energy-efficient computer centres (see DESY inForm 02/2011). Now the DESY environmental team plans to raise awareness for environmental issues at DESY. "This year we are going to post monthly information on green topics this at DESY," explains Franziska Becker from the environmental team. Topics will include peak hours and indoor climate. The environmental team members come from different DESY groups and support the D5 department in environmental matters.

As far abck as 2004, DESY participated in the ECOPROFIT project which is supposed to realise environmental measures that also reduce cost. DESY took part in workshops and carried out environmental protection measures within the framework of this programme. With the successful conclusion of the project, DESY was awarded and became an environmental partner of Hamburg.

DESY is also active in the follow-up ECOPROFIT Club. Their programme includes both implementation of and reports on environmental protection activities. The best moment to do this is 2011, the year of Hamburg being the European Green Capital. More information will be available on the postings of the environmental group and – of course – in DESY inForm. *(gh)*

Even more new ideas

Developments and new proposals at the accelerator marketplace of ideas

After only two events, the DESY accelerator marketplace of ideas is on the right path to becoming a tradition. The contributions to the marketplace of ideas in summer 2010 (see DESY inForm 09/2010) have been evaluated and the gathering of ideas for new projects at DESY's accelerators, for new technologies, improvements and analysis methods goes on. The second marketplace of ideas took place at the end of 2010, the third one is scheduled for September 2011.

Obviously DESY people and accelerator experts from other institutes are not running out of ideas: the agenda of the second marketplace of ideas includes not only the review of 13 previoulsy proposed projects and the presentation of planning progress; but also the presentation of a total of 15 new ideas to the market with a report of ten minutes followed by a discussion of five minutes (following the marketplace "tradition"). Among the proposals were new accelerator technologies such as plasma wakefield acceleration or the plan to set up a new beamline for machine studies at FLASH. "The follow-up of the proposals is going ahead," says organiser Elmar Vogel, "smaller projects have already been implemented, larger projects show concrete simulation results and feasibility studies." The time is right for new development projects in the field of accelerator physics and technology: recently there was an application to include accelerator research and development (ARD) as an independent topic in the portfolio of the Helmholtz research field "Structure of Matter". The funding decision for the next four years is expected in spring 2011. Six Helmholtz centres are participating in the ARD initiative (including DESY as programme coordinator), and more than ten additional institutes and universities are cooperating as collaboration partners. Many of the project proposals of the accelerator marketplace of ideas fall into the subtopics of the funding area: superconducting accelerator technology, new particle sources, electron-photon interaction, ring accelerators and new acceleration concepts for extremely high gradients. Perhaps, with the help of ARD, the first proposals from the marketplace of ideas will soon become a funded project. *(baw)*

INFO

http://beschleuniger-ideenmarkt.desy.de

Hope for Alzheimer patients

Potamkin Prize for Eva-Maria and Eckhard Mandelkow

For their work on Alzheimer's disease, Eva-Maria and Eckhard Mandelkow from the Max Planck Research Group at DESY were awarded the renowned Potamkin Prize from the American Academy of Neurology. The 100 000-dollar prize will be shared evenly between three researchers in all, and will be presented to the Mandelkows on 14 April at the annual meeting of American neurologists in Honolulu.

Using the DORIS storage ring, the work of the Max Planck researchers included identifying the structure of important molecules to investigate the causes of Alzheimer's disease. In new mouse trials they have succesfully demonstrated that a loss of memory caused by the deposits of the so-called Tau proteins in the brain is reversible – a great hope for effective future therapies. It seems that the toxic agent of the Tau protein largely disappears when the corresponding Tau gene is switched off. Mice with a human Tau gene that had previously shown symptoms of dementia, regained their ability to learn and remember, and the synapses of the mice also reappeared in part once the gene is deactivated. The scientists are now testing active substances to prevent the formation of Tau deposits in mice. This may help to reverse memory loss in the early stages of Alzheimer disease – in part at least. *(uw)*

Happy anniversary!

8 March is the 100th anniversary of the International Women's Day. On this occasion, many DESY women join the celebrations in the Chamber of Commerce and Industry at an event highlighting women in science. More information on the 100th International Women's Day at **www.frauentag-hamburg.de**

Theory is behind everything

Interview with string theorist Volker Schomerus

Volker Schomerus, head of the DESY Theory Group, was recently awarded the "Gay-Lussac Humboldt Prize" for his excellence and commitment in Franco-German research collaboration. DESY inForm asks what theorists are up to at DESY.

Do theorists still use blackboard and chalk at work?

Schomerus: Yes. When you calculate theories, especially in discussions, it is still the best way to do it. However, I also often use the computer to bring my thoughts in order – but for equations the blackboard or paper and pencil are just the right thing.

You work on quantum field and string theories – what exactly do you do there?

These two fields are growing together. Quantum field theory has a long history of success: since its beginning in the thirties of the past century, important contributions from many leading theorists turned quantum field theory into a basis for physics and particularly for the Standard Model. Nevertheless, until today, we fight against incredible technical and conceptual difficulties. This is where string theory can help.

Theorists are often criticised - for example regarding string theory - of being removed from reality because no one is actually able to test it.

Although perhaps no one should expect that strings can be proven directly at accelerators, the string theory is much closer to the experiment than generally assumed. Indeed, it looks like we are able to solve the quantum field theory problems, including the Standard Model, with string theory methods – with unforeseen efficiency. String theory offers approaches no one thought of 15 years ago.

Are theory and experiment close enough to make it necessary for you to work at DESY?

Theorists need an interdisciplinary environment to make an exchange of ideas and problems possible. Most important for me are strong mathematics, experts in solid state physics and people who work on the description of high energy experiments. We don't need a daily discussion with the experimentalists, but good theory needs a certain critical mass. We have that at DESY.

You were awarded with a Franco-German prize. What are your connections with France?

I did research in France for three years and still have close contacts, especially with my colleagues from Paris. We are planning joint workshops and publications, and an exchange of our young scientists. This is also supported by DESY. *(tz)*

The target cell (at right in the foreground) has been built into the DORIS accelerator. In the background, the OLYMPUS toroidal magnet coil.

Now again: collisions at DORIS

The target system of the OLYMPUS experiment has been installed

When accelerators are switched off, physicists are spinning. Uwe Schneekloth can tell you a story about this. During this winter shutdown, he and his colleagues have brought the OLYMPUS experiment a substantial step forward. Large sectors of the fixed-target experiment, which is supposed to deliver precise information about the relationship between electric and magnetic charge distribution in the proton, was installed in an extensive retrofitting: the complete interaction region was integrated into the accelerator and equipped with a target cell in which, from above, hydrogen is fed into the collision area and then immediately exhausted from the vacuum.

The shielding was extended to make the whole detector fit into it. Moreover, the accelerator physicists converted the DORIS accelerator, to allow quick switching between electrons and positrons – an important feature to make the OLYMPUS experiment run successfully. Except for the vacuum pump that broke down when transforming the electronics from 110 to 230 volts, everything ran quite smoothly.

The "olympians" show no signs of fatigue. They looked forward excitedly to the first data taking shifts in which they could put their experiment into operation. "Now we are able to collide the DORIS positrons with our hydrogen target, test all systems and measure first electron proton scattering," Schneekloth explains. The installation of the whole experiment is scheduled for summer; final measurements are to start in 2012. *(tz)*

HELMHOLTZ ASSOCIATION

Ion tumor therapy refined

The already very effective tumour therapy using ion beam pulses is being further developed to optimise the irradiation dose for each individual patient. So far, radiation therapy takes into consideration in particular the consistency and position of the tumour. The GSI experts initially work on samples of tumour tissue prepared to remain alive over weeks. Since these samples largely correspond to the natural conditions within the patient, the scientists can observe effects during irradiation, which also occur in patient treatment. In particular, the scientists want to find out how the irradiated cells affect their neighbouring cells, that is, observe the so-called bystander effect. Until now, this is possible only to a very limited degree in the hitherto existing test procedures with artificial cell samples or in animal experiments.

www.helmholtz.de/hermann

Imprint

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DESY-PR
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LHC will run to the end of 2012

The CERN management has decided to bring protons and heavy ions to collision at the Large Hadron Collider LHC at CERN for two years after its winter shutdown. As of 2013, there will be a long phase of upgrade to make the machine ready for operation at full energy. This will give the experiments a good chance to discover new physics.

Night and Day

On Friday, 4 March at 8 p.m., the DESY Choir will give a joint concert with a string quartet in the DESY canteen. The programme features mainly musical songs from the years 1930 to 1950, the "golden time" of American musicals. The programme is complemented with jazz-style music from the same era. Admission is free!