Photon Science at DESY

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The year 2007 was marked by very successful user operation of DORIS III and DESY’s Free Electron Laser FLASH where the nominal electron energy of 1 GeV of the linear accelerator and lasing at 6.5 nm – another world record - were achieved. The construction of PETRA III is in full swing: On September 14th, 2007 we had the laying of the foundation stone ceremony and on November 26th, 2007 the topping-out ceremony together with Minister A. Schavan and O. von Beust, the First Mayor of the City of Hamburg. The Center for Free-Electron Laser Science CFEL pursued in a cooperation of DESY with the University of Hamburg, the Max-Planck Society and the City of Hamburg, was founded and the first two leading scientists have been appointed.

The kick-off meeting for the European XFEL Facility on June 5th, 2007 was the highlight of the year. As indicated in the preface by A. Wagner and detailed in this Annual Report, very important mile stones have been reached for the realisation of the European XFEL Facility in the year 2007. A crucial step forward was the decision of the Russian Federation to join XFEL and to make a large financial contribution to its realization. This decision refers to an intergovernmental agreement between the Russian Federation and the Federal Republic of Germany on “Collaboration in the Development and Application of Accelerator Based Photon Sources” which was signed by A.A. Fursenko and A. Schavan, the ministers for education and research of the Russian Federation and the Federal Republic of Germany on October 15th, 2007 in Wiesbaden.

In 2007 the DORIS III machine operation achieved an average availability of 95.0%. The user operation started on January 18th and ended December 21st yielding 5660 hours for scheduled user experiments which was used by about 2100 scientists. In 2008 there will be an extended shutdown until September due to reconstruction work at the PETRA III / DORIS III pre-accelerators.

Volume rendering of the head and thorax of the sawfly Tenthredo vespa. The absorption-contrast µ-tomography was performed at beamline BW2 of DORIS III using a photon energy of 8 keV. Due to the large and incoherent source, pure absorption-contrast can be applied at low photon energies to visualize the different parts of the external and internal anatomy of the sawfly, e.g. the different types of muscles, antenna, eyes, etc. (Scale bar: 1 mm). For details see annual report of: F. Friedrich, H.W. Pohl, F. Hünefeld, F. Beckmann, J. Herzen and R.G. Beutel (in this part).
The scientific output at DORIS III was most remarkable, the number of DORIS III reports increased by more than 20%. The Annual Report contains an all-time high number of 975 reports on experiments performed this year at HASYLAB by external users, including structural biology. The list of groups involved in the preparation and performance of experiments at HASYLAB in 2007 contains 379 institutes and about 1700 scientists (including about 110 FLASH users). In the field of structural biology about 590 scientists from 184 institutes, primarily from Europe, used the EMBL and MPG beamlines and facilities at DESY. The reports on their experiments are collected in part II of the Annual Report. As in the preceding years, the authors are fully responsible for the content and the layout of their reports.

Following the request made by the Senate of the Helmholtz Association in the context of the strategic evaluation (2004) of the Program on “Large Scale Facilities for Research with Photons, Neutrons and Ions”, a review of the DORIS III facility against the background of the construction of PETRA III was conducted on September 7th, 2007. We thank the expert group for the effort made in evaluating the DORIS III facility, both with respect to its past and current performance and its future operation.

DESY is very pleased with the comments made by the expert group concerning the scientific importance and originality of the research at DORIS III including the statements

- "Each year, a number of scientific breakthroughs are reported in prestigious journals such as Nature, Science and Physical Review Letters."
- "The list of publications in the period 2004-2006 and the impact analysis presented by the management testify that the quality of the research is very good and in some areas unique and excellent."

We are also very pleased about the concluding recommendation of the review panel to operate PETRA III in parallel with a reduced number of DORIS III beamlines in the next HGF funding period 2010-2014. We agree to the statement according to which "the best joint operation mode would be one in which the research groups operating PETRA beamlines also take charge of the complementary beamlines at DORIS. These groups should keep the beamlines at both facilities up to date and refer the users to the facility that suits their research purpose best." In this spirit DESY will follow the advice to "Make DORIS part of PETRA". As a result of the numerous discussions, also in the Photon Science Committee and the Extended Scientific Council of DESY, we have a clear picture how to present DESY’s storage ring activities at the upcoming strategic HGF evaluation of the PNI program in 2009, and we would like to thank everybody involved for their help.

New brochures presenting the DESY research activities in Photon Science to a broader public. The goal of the FLASH brochure is to explain the novel technologies and the free-electron laser principle on a level which should be useful to graduate students if they want to understand things beyond pure excitement, but also to scientists who may become interested in using this new tool for their own research.
Right after the final shutdown of HERA on June 30th, the dismantling of the PETRA II ring started, which had been used as a pre-accelerator for HERA. The 1/8 of the ring next to the HASYLAB office building was completely removed as it is the site of the new experimental hall. In parallel the dismantling of the remaining 7/8 of the storage ring began, with the removal of all quadrupole, sextupole and dipole magnets. After cleaning of the ring tunnel the installation of a new cooling water distribution system, changing of the power supply lines as well as the installation of the refurbished magnets started. The construction of the new experimental hall progressed very rapidly and at the end of December the steel fiber-enforced, one meter thick and about three hundred meter long and 20 meter wide concrete base plate was casted.

In parallel to the construction activities the prototyping phase of the beamline front-end components was completed and the series production of these devices has been initiated early in 2007. The first two prototypes of the generic liquid nitrogen cooled double crystal monochromator have been delivered. One of them is currently being tested under high heat load conditions at beamline ID6 of ESRF (Grenoble). Extended mechanical tests are carried out on the second one by the HASYLAB metrology group. The design work of the experimental stations continued in close collaboration with the user community. Seven workshops were organized in order to discuss the design options with future users and external experts. According to the present schedule, first installation work on the experimental floor will take place in April 2008. The installation of first beamline components will start mid 2008. After a very tight installation schedule the technical commissioning of the storage ring will start in October 2008. Beamline commissioning is scheduled to start in spring 2009 and first “friendly” users are expected mid to end 2009. Regular user operation for the first beamlines at PETRA III is scheduled for 2010.
In 2007 the impressive success story of FLASH continued. Until end of March 1785 hours of scheduled operation providing 972 hours of scheduled time for users, 483 hours for FEL studies and 330 hours for accelerator studies, i.e. 54% of the scheduled time was delivered for user experiments. Work during an extended shutdown from April to the end of September 2007 included installation of new cryo-modules in the linac, the installation of a new insertion device for production of IR radiation and a beamline for transport of the radiation into the experimental hall of FLASH. After a commissioning period until end of August, the nominal linac energy of 1 GeV was achieved on September 21st, 2007 and only two weeks later, on October 5th, 2007 lasing at the nominal wavelength of 6.5 nm was observed. On November 26th the second period of user runs in 2007 started.

FLASH results were published in high impact journals. As a most recent example we refer to a study by Sorokin et al. (Phys. Rev. Lett. 99, 213002 (2007)) on the photoionization of Xe atoms at ultrahigh intensities of 13.3 nm radiation. Irradiance levels from $10^{12}$ to $10^{16}$ Wcm$^{-2}$ were achieved by strong focusing of the beam. Ion charges up to Xe$^{21+}$ were observed and investigated as a function of irradiance. The observed surprising multi-photon excitation effects are currently being discussed in terms of a perturbative and a non-perturbative description.

The European XFEL Facility will be realized in strong collaboration between the XFEL company to be founded and DESY. DESY leads an international consortium for the construction of the accelerator complex, the XFEL GmbH will lead the realization of the photon beamlines from the undulators to the instruments in the experimental hall. DESY also has a strong interest to get involved in the construction of the photon beams. As an example the DESY Photon Science detector group leads a consortium for the construction of the Analogue-Pipeline Hybrid Pixel Detector (HPAD) for the European XFEL. Contract negotiations between the HPAD consortium (DESY/PSI/Uni-Bonn and Uni-HH) and the European XFEL are finished and the official start of the project is January 1st, 2008.
The Center for Free-Electron Laser Science Hamburg, CFEL, will play a central role in DESY’s involvement in the scientific use of the free-electron laser facilities in Hamburg. CFEL shall become a major interdisciplinary research center opening the possibilities of the FEL technologies for a wide range of scientific challenges. It shall perform basis research and explore the possibilities to perform routine experiments for scientific investigations and technological applications. It will further contribute to the necessary training and education to ensure the dissemination of the knowledge generated into the academic and technological communities. The collaboration contract between DESY, the University of Hamburg, the Max-Planck Society and the City of Hamburg has been signed. The funding for a new laboratory and office building for CFEL by the City of Hamburg is ensured. Prof. Henry Chapman from Lawrence Livermore National Laboratory, USA, and Prof. Andrea Cavalleri from Oxford University, UK, are the first two leading scientists in charge of experimental core groups of CFEL and will start work in January and summer 2008, respectively.

CFEL will be made up of several groups from the contributing partner institutions: A Max-Planck Research Group at the University of Hamburg including 2 experimental Core Groups and 3 Independent Junior Research Groups, 3 Core Groups from DESY, Advanced Study Groups from MPG and University of Hamburg combining the FEL activities of different institutes, and a coordinated activity for the development of novel detectors.

The users of the DESY Photon Science facilities have been very successful in attracting third party funding for their work at FLASH and PETRA III. In the frame of the so called “Verbundforschung” of the German Ministry of Education and Research 18 university groups will receive 15M€ for their activities at FLASH over the coming 3 years. The Ministry has grouped its efforts in a center called “Matter in the light of ultrashort and extremely intense x-ray pulses” which is lead by Prof. Wilfried Wurth from the University of Hamburg. For work at PETRA III the “Verbundforschung” granted 12M€ to 11 university groups.

We would like to take the opportunity to thank the funding agencies for their generous support of the university groups for research at the forefront photon science facilities of DESY. The close collaboration between DESY and the universities in developing novel instrumentation has been instrumental for the success of the laboratory and research with Synchrotron Radiation and Free-Electron Lasers in Germany.
The achievements made in the year 2007 in photon science at DESY were only possible due to the high motivation of the staff of the DESY Photon Science Department, of all the colleagues at DESY and the various outstations at DORIS III. The interplay with our users and their strong commitment to the facility are crucial for the success of the laboratory and are very much appreciated. We are facing fascinating times for research with photons at DESY.

After 18 years of working at DESY—including nine years as Director for Photon Science—I shall retire at the end of this year and I would like to conclude this foreword with a more personal outlook.

When I started as deputy director of HASYLAB in 1989, DESY was in the middle of constructing HERA. This year the very successful operation of HERA came to an end, and we are now building PETRA III and heading for construction of the European XFEL facility. DORIS III will be operated in tandem with PETRA III in the years to come. DESY’s in-house research in photon science and the life science activities of EMBL and of the Helmholtz Association will be strengthened. The Center for Free-Electron Laser Science CFEL will offer best conditions for optimal use of FLASH and XFEL by DESY scientists and the German photon science community as a whole. Embedded in the strategic Helmholtz Alliance “Physics at the Terascale”, DESY’s particle physics programme is at the centre of a large national effort to make best use of the LHC at CERN in Geneva and prepare for ILC.

Substantial changes have been made and, again, DESY’s science programme is outstanding, the new facilities are among the best in the world. These changes demonstrate the extraordinary spirit of the laboratory and its staff—a solid basis for future success.

I very much enjoyed working at DESY, as well as working with the photon science community as a whole, and I would like to thank you for the strong support which I received from many of you over these years. In January 2008 I shall start working at SLAC in Stanford, USA, where the Linac Coherent Light Source LCLS is expected to deliver 0.15 nm FEL radiation in summer 2009. One of the goals of my new job is to strengthen the collaboration between DESY and SLAC in all aspects of FEL science.

Let me finish with my very best wishes for a good future to all of you!

Jochen R. Schneider
Director of HASYLAB