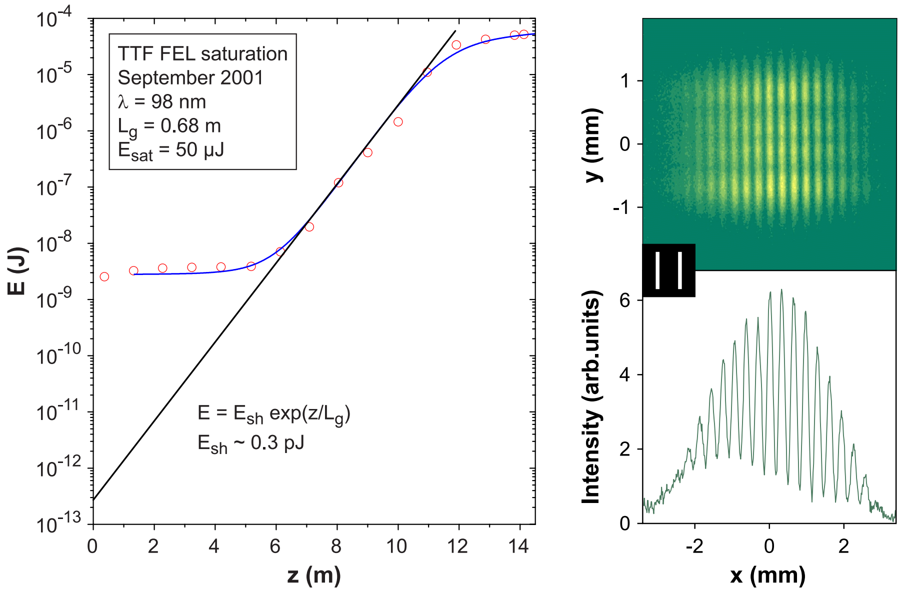
Preface

J.R. Schneider

At the Hamburger Synchrotron Radiation Laboratory HASYLAB synchrotron radiation emitted from positrons in the DORIS III and PETRA II storage ring is used in many different ways in fundamental and applied research in the fields of physics, biology, chemistry and crystallography, in materials and geological sciences as well as in medical applications. This is done by using a wide spectrum of electromagnetic radiation ranging from the visible to the hard X-ray regime and covering an energy domain from about 1 eV to 300 keV. In addition to operating the user facility, HASYLAB staff contributes to the training of students in physics via a close collaboration with the II. Institute of Experimental Physics of the University of Hamburg.



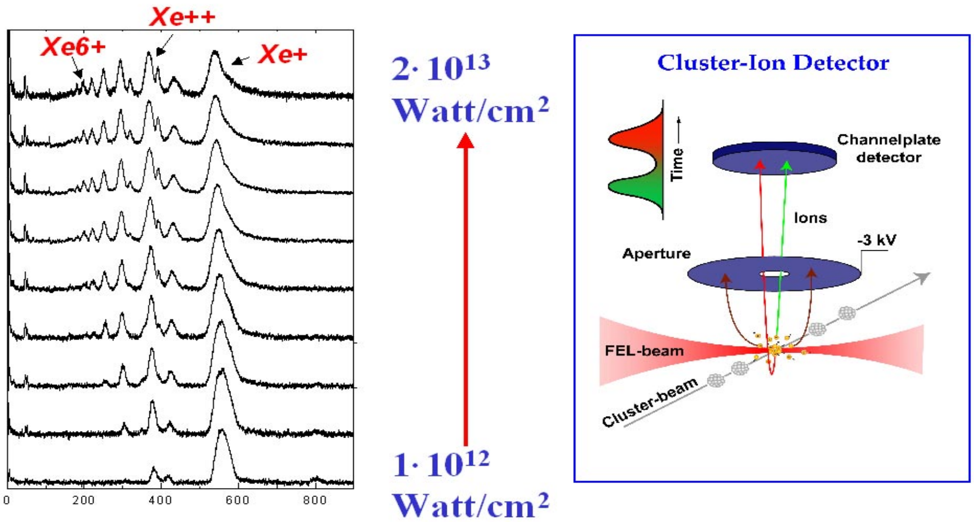
Average radiation pulse energy as it develops along the undulator. Circles are experimental data, the solid line is a numerical simulation. For more details see the article written by K. Tiedtke. Right: Diffraction of 95 nm FEL radiation from a double slit, observed by a CCD camera on a Ce:YAG crystal. The slits were 200 µm wide, 2 mm long, and 1 mm apart.

(*Tesla Test Facility Team*)

At nine experimental stations the structure of bio-molecules is studied by scientists of the Hamburg Outstation of the European Molecular Biology Laboratory (EMBL) and by three research units for structural molecular biology of the Max-Planck-Society. A new experimental station for protein crystallography, built and operated by a consortium of EMBL, the Institute for Macromolecular Biology (IMB) in Jena and the Institute for Medical Biochemistry and Molecular Biology of the University Hospital Hamburg Eppendorf, became operational in the fall of 2001. Recently the commitment of EMBL to the Hamburg Outstation was strongly enlarged. The number of permanent positions available at the outstation will increase from 29 in the year 2000 to 38 in the year 2003, the outstations office and laboratory space will be enlarged by 400 m^2.

After two years of preparation the biotech firm Thetis-Institute of Bio-molecular Natural Products Research (IBN), Hamburg, started operation on the DESY site. Thetis-IBN GmbH offers to the pharmaceutical and agrochemical industry the complete range of agent development starting from the provision of marine macro- and micro-organism, followed by isolation and structural analysis of the active substance, structure-activity relation, agent-receptor relation, proteom analysis and toxicology up to clinical studies. The firm's technical equipment, including 3 Bruker Avance NMR spectrometers at 600 and 800 MHz, respectively, and 2 mass spectrometers, very nicely complements the experimental stations for structure research in molecular biology at the DORIS III storage ring.

The scientific perspectives and the technical realization of TESLA, as documented in the Technical Design Report, has been presented in the frame of a scientific colloquium on 23/24 March 2001 at DESY. The meeting, attended by more than 1000 participants, 40% from outside Germany, created an extraordinary excitement about the new science coming in reach with the Linear Collider and the X-ray Free-Electron Laser Laboratory. The status of the project is described by Albrecht Wagner in a special contribution to this Annual Report.



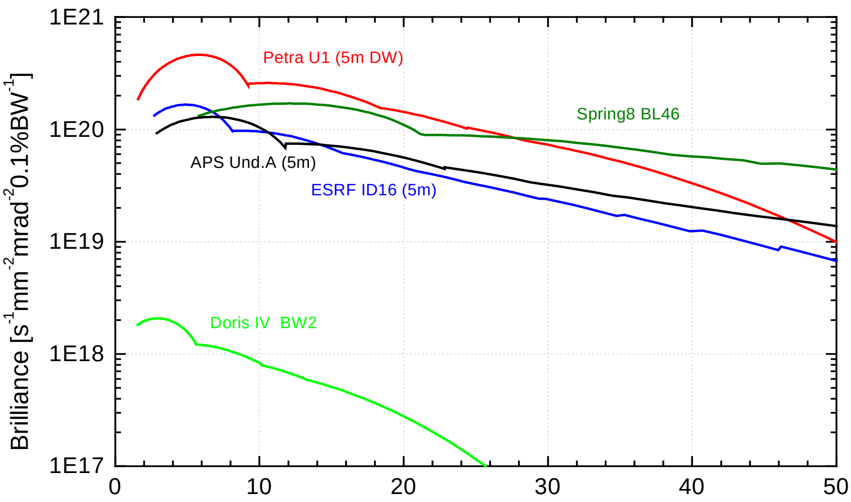
Time-of-flight mass spectrum recorded with FEL radiation at 98 nm in single shots after multi-photon ionisation of Xenon clusters comprising 50 atoms. The photon pulse length is of the order of 50 fs, the power density varies between $1 \cdot 10^{12}$ at the bottom and several 10^{13} Watt/cm^2 at the top of the figure. A schematic illustration of the cluster ion detector is given in the right part of the figure. Ions with high kinetic energy are split into two lines. Details are given by H. Wabnitz et al. in a special contribution to this Annual Report.

(*H. Wabnitz, P. Gürtler, K.v. Haeften, T. Laarmann, W. Laasch, J. Schulz, A. Swiderski, T. Möller)*

At the free-electron laser at the TESLA Test Facility (TTF) saturation of the SASE process has been reached on 10 September 2001 at 98 nm, which is the shortest wavelength achieved so far with free-electron lasers. Peak powers of 1 GW have been reached at pulse lengths in the range of 30-100 fs, the measured peak brilliance of 10^{28} photons/(sec·mrad^2·mm^2·0.1% bandw.) was indeed 9 orders of magnitude higher than the value achieved today at the best 3rd generation synchrotron radiation facilities in this wavelength range. The average power was approximately 5 mW, the average brilliance 10^{17} photons/(sec·mrad^2·mm^2·0.1% bandw.). The radiation was carefully characterized and all results agree very well with theory. This success is regarded world wide as a break through on the way to the 0.1 nm X-ray laser.

Only a few weeks after reaching saturation at the TTF FEL first ablation experiments were performed successfully. The measured damage levels support the assumptions made when defining beamlines and optical elements for the VUV FEL user facility, which will be available in 2004. In another experiment Coulomb explosion was studied on free Xe clusters. By focusing the beam down to 20 µm diameter a photon density of approximately $10^{18}/(\text{sec}\cdot\text{cm}^2)$ was achieved, which corresponds to a power density of $2\cdot10^{13}$ Watt/cm^2. The power density could be varied by a factor of 20 by moving the cluster beam out of the

focus of the laser beam and very exciting first results were obtained. Although the incident photon energy of about 12 eV is just above the lowest Xe ionisation potential, higher ionisation states of up to 8+ were observed by means of a time-of-flight mass spectrometer. The kinetic energy of Xe^{7+} ions from clusters containing 2000 atoms is as high as 2500 eV.

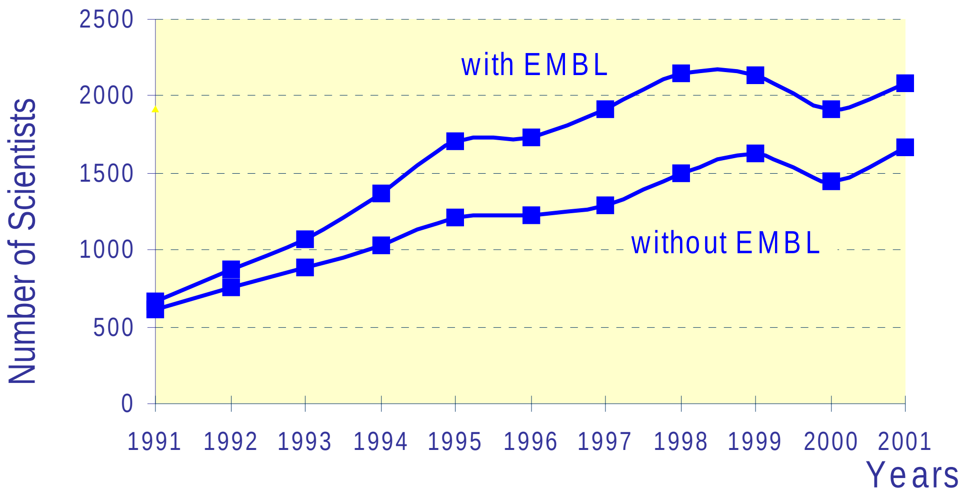


Comparison of the brilliance expected from a fully tunable undulator proposed for the upgraded PETRA storage ring including damping wigglers with the values achieved at existing 3rd generation light sources. Comparison is also made with the expected performance of a wiggler in an upgraded DORIS storage ring.

Studies for possible upgrades of the DORIS and PETRA storage rings have been finished. The results are presented by Klaus Balewski et al. in a separate contribution to this Annual Report. The two options were first discussed with representatives of HASYLAB's main user groups during a workshop in July, and later in an open workshop on 11/12 October 2001, which was attended by 150 users. In agreement with the recommendations of the "Komitee für Synchrotronstrahlung", representing the German synchrotron radiation user community, there was a clear preference at this meeting for the PETRA option, assuming that the operation of the DORIS storage ring in its present configuration will be continued. At PETRA the level of performance of today's 3rd generation can be surpassed if additional damping wigglers are installed. A section of 1/8 of the 2.3 km circumference of the PETRA storage ring has to be rebuilt completely allowing for the installation of about 13 undulator beamlines. In agreement with recommendations of the Extended Scientific Council and the Administrative Council of DESY the decision was made to start building a dedicated synchrotron radiation facility in the PETRA storage ring in January 2007. The detailed design work for this facility will start in January 2002. Next a choice will be made between the options to either modify the existing booster ring or to build a second, new ring in the existing PETRA tunnel. In order to realize this project additional funds for civil engineering, equipment and personal are needed.

Coming to current synchrotron radiation research at HASYLAB, DORIS III was operated from 15 January to 17 December 2001 with positrons at an energy of 4.5 GeV and initial currents of up to 150 mA in the 5 bunch mode of operation. Typical lifetimes are 10 hours in the beginning and 20 hours at the end of a 8 hours run period. The 5348 hours of scheduled dedicated user time were grouped in 8 blocks of about 5 weeks each, separated by one week for maintenance. To optimize DORIS operation eight-hour machine shifts were inserted on the second, third and fourth Thursday of each beamtime block. From 9 to 23 July 2001 an additional short shutdown was scheduled. For experiments which need a special time structure, the storage ring was operated in reduced bunch mode for about 20% of its running time. Because of technical problems discussed in a contribution by Ortwin Kaul and Werner Brefeld the operation efficiency of DORIS III was 91.7% and did not reach the level of performance of 94.4% of the year 2000.

At the PETRA storage ring 3100 hours of dedicated beamtime were provided in 2001. Dedicated running was possible because of the upgrade shutdown of the lepton-hadron-collider HERA. In dedicated user mode the lifetime was approximately 12 hours at an average current of 37 mA. 21 different experiments could be performed.



Number of scientists involved in experiments performed at HASYLAB over the last 11 years.
(Users coming for more than one beamtime per year are counted only once)

During the winter shutdown 2000/2001, lasting 4 months, new vacuum chambers for the quadrupole triplets have been installed in order to remove the mutual mechanical coupling of these components. Because the 3 injection kicker magnets were completed in time, not all of the new vacuum chambers could be installed. Nevertheless the horizontal movements of the beam orbit in the storage ring was reduced by a factor of 5, which lead to a significant improvement of the synchrotron radiation beam stability. It is planned to install the new kicker magnets and the remaining new vacuum chambers in the winter shutdown 2002/2003.

The HASYLAB Annual Report 2001 is again published as a CD-ROM and an internet version, only a limited number of hard copies will be provided. It contains 704 reports on experiments performed this year at HASYLAB, including structural biology. The list of groups involved in the preparation and performance of experiments at HASYLAB in 2001 contains 252 institutes and about 1662 scientists. In the field of structural biology about 392 scientists from more than 86 institutes, primarily from Europe, used the EMBL beamlines and facilities at DESY. The reports on their experiments were collected in a second section of the Annual Report. As in the preceding years, the authors are fully responsible for the content and the layout of their reports.

Examples of in-house research performed over the last three years by HASYLAB staff and scientists from permanent guest groups on site have been collected in a new brochure entitled “Research at HASYLAB”, which is available at the HASYLAB secretariat. The prime aim of the brochure is to convince students and young scientists to get involved in synchrotron radiation research.

It is a great pleasure to congratulate Professor Kenneth Holmes, Max-Planck-Institute for Medical Research Heidelberg, who received the European Latsis Award for his pioneering synchrotron radiation work, and the Gregori-Aminoff-Award for his ground breaking development of synchrotron radiation techniques for structure determination of biological macro-molecules, especially muscle proteins. Professor Jochen R. Schneider, HASYLAB, received the 2nd edition of the Prize of the European Crystallographic Association for his pioneering work on the application of γ-ray spectroscopy and his high energy synchrotron radiation studies, as well as his more recent involvement in the development of the free-electron laser. We are very pleased to congratulate Dr. Helmut Ehrenberg, Institute for Materials Science at the Technical University of Darmstadt, who received the Max-von-Laue Prize of the German Crystallographic Association for his outstanding powder diffraction work with synchrotron radiation. He also received the Adolf-Messer Prize from the Technical University of Darmstadt. With great pleasure we congratulate Dr. Harald Reichert, Max-Planck-Institute for Metals Research in Stuttgart, who received the Walter-Schottky-Award of the German Physical Society for his innovative work on solid-liquid interfaces using high energy synchrotron radiation, which lead to the discovery of the local 5-fold symmetry in liquid lead.

Professor Gerhard Materlik was appointed Chief Executive Officer of the UK’s new synchrotron radiation facility DIAMOND at the Rutherford Appleton Laboratory. Since 1978, when he joined DESY, Gerhard Materlik had a most important impact on the synchrotron radiation activities at HASYLAB due to his competence and scientific creativity, as well as due to his efficiency in administrative matters. He was in charge of the construction of the bypass extension at the DORIS storage ring providing HASYLAB with 7 highly competitive wiggler beamlines. More recently he co-ordinated and stimulated the efforts for an X-ray free-electron laser laboratory as part of the TESLA project. We wish Gerhard Materlik all the success for his work at DIAMOND and look forward to a continuation of our very successful collaboration.

Thanks to the high motivation of the HASYLAB staff and of the external users of the laboratory, HASYLAB is facing promising years with exciting synchrotron radiation research. The support of synchrotron radiation research by all colleagues at DESY is very much appreciated.

Jochen R.Schneider
Director HASYLAB