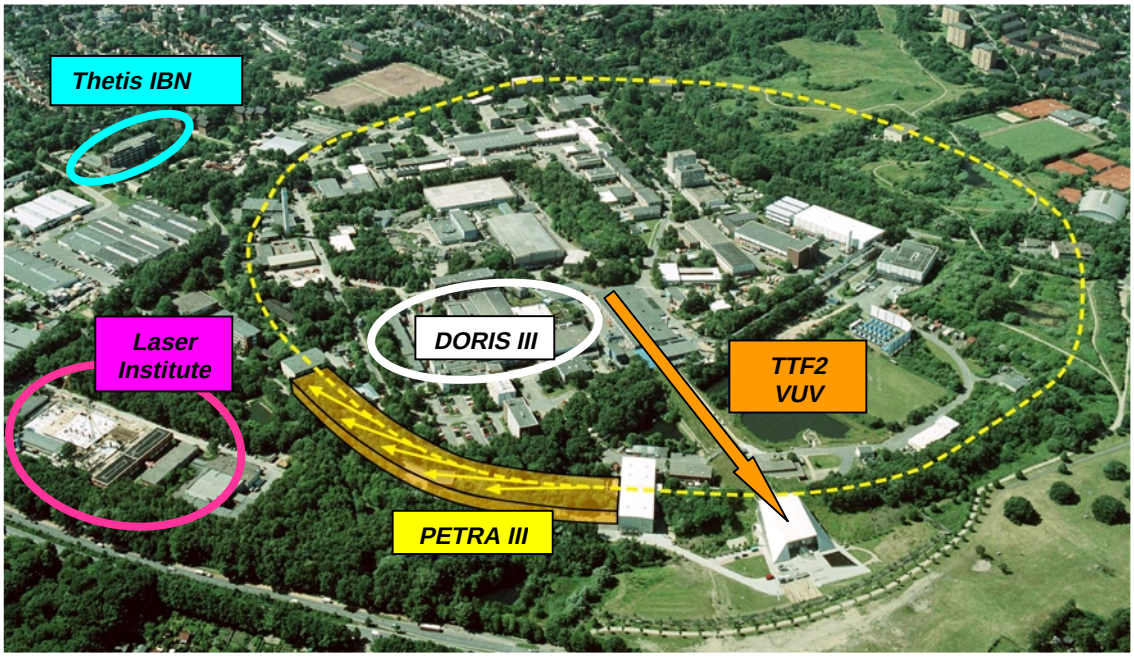
Preface

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 Institute of Experimental Physics of the University of Hamburg.



Research with photons at DESY:

The DORIS III storage ring best used for synchrotron radiation experiments needing high photon flux, the PETRA storage ring intended to be upgraded to provide 13 high brilliance undulator beamlines, the VUV FEL user facility at the TESLA Test Facility providing laser radiation down to wavelengths of 6 nm, the Laser Institute of the University of Hamburg, the bio-tech company Thetis-Institute of Bio-molecular Natural Products.

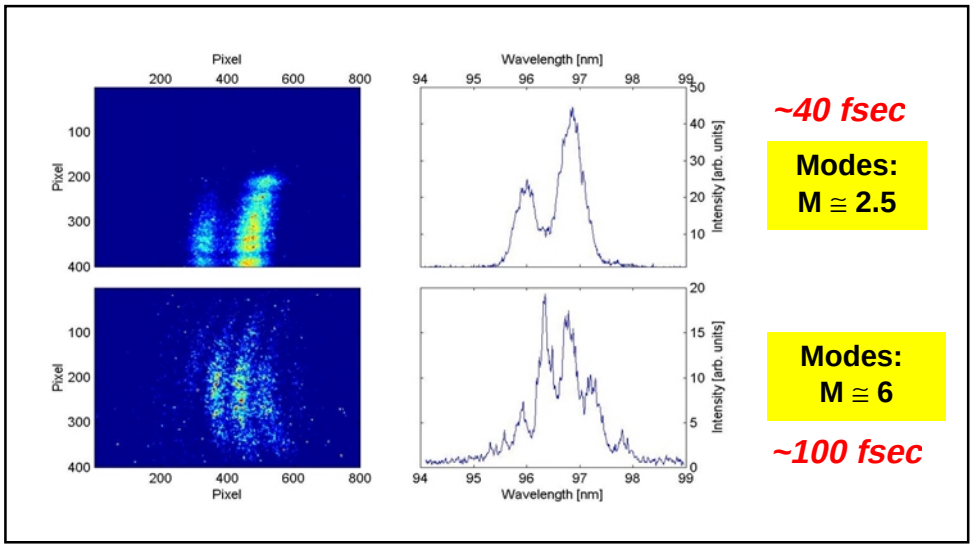
The new office and laboratory building of the Laser Institute of the University of Hamburg on the DESY campus is completed. The colleagues will move into the building during the first half of 2003. Early next year a new C4 position for short time X-ray laser physics at the Institute for Experimental Physics of the University of Hamburg will be offered. All of us expect very strong synergy effects between the activities using light in the optical and in the X-ray wavelength range, respectively.

The GKSS Research Center in Geesthacht, together with DESY and the Geoforschungszentrum Potsdam GFZ, builds a new high-energy synchrotron radiation beamline in the HASYLAB I hall providing X-rays in the energy range from 30 to 200 keV. The main emphasis will be on studies of residual stress and texture by diffraction and on imaging of pores, particles and precipitates using tomography techniques. The GFZ will install a MAX2002 high pressure device and perform diffraction experiments on larger samples of geological relevance. All instruments will be operated as user facilities open to scientists from universities, research institutes and industry.

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 further experimental station for protein crystallography is 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. 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. In 2002 the outstations office and laboratory space was enlarged by approximately 400 m^2.

The bio-tech company Thetis-Institute of Bio-molecular Natural Products Research (IBN), Hamburg, which offers to the pharmaceutical and agrochemical industry the complete range of agent development had its first year of successful operation. The 3 Bruker Avance NMR spectrometers at 600 and 800 MHz started operation.

The emphasis of the industrial activities at HASYLAB supported by our industrial service group is on absorption spectroscopy on catalytic systems with increasing interest in in-situ studies combined with diffraction experiments and other on-line characterisation techniques. The boundary conditions for industrial use of the HASYLAB facilities including prices, especially for proprietary research, have been described in a new flyer for industrial users available at the HASYLAB secretariat. At the beamlines operated by the EMBL outstation and the MPG groups for structural molecular biology the industrial use of beamtime for protein crystallography increased significantly.



Single shot spectral distributions for pulses of about 40 and 100 fsec achieved at TTF1 SASE FEL:

By changing the bunch compression scheme the duration of the photon flash is varied which is reflected in the measured single shot spectral distributions. On the left pictures taken with a CCD camera after the normal incidence monochromator are shown, in the vertical the distribution of the beam intensity perpendicular to the plane of diffraction is displayed. Cuts along the wavelength dispersion parallel to the horizontal axis are shown on the right. (see contribution by the TTF FEL team to the 2002 HASYLAB Annual Report and Eur. Phys. J. ***D20*** *(2002)149-156)*

The design studies for the upgrade of the PETRA storage ring to a first class 3rd generation synchrotron radiation facility were started with the goal to provide the Technical Design Report for PETRA III at the end of 2003. In order to understand the needs of the potential user community 5 workshops have been organised:

- Materials science (together with GKSS)
- Structural biology (together with EMBL, MPG and Hamburg University)

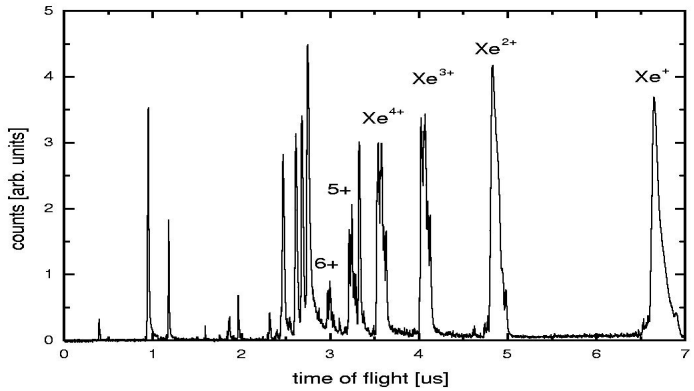
- Spectroscopy
- Condensed matter physics
- VUV and soft X-ray spectroscopy

About 400 participants attended these workshops and the response of our user community was very encouraging. A first suggestion of the layout of the experimental hall and the different types of beamlines to be realised at PETRA III will be presented and discussed at a public workshop in summer 2003.

Phase 1 of the SASE FEL activities at the TESLA Test Facility has been concluded successfully. The following milestones have been reached:

- Tuneability at saturation in the wavelength range 80-120 nm.
- Peak brilliance as expected.
- 1 GW peak power at 100 nm in 50-100 fsec long pulses.
- 10^{13} photons in flashes of 50 fsec duration focused into a cross section of 20 µm diameter.
- Observation of 2nd harmonic (50 nm).
- All experimental observation are in full agreement with SASE FEL theory.
- First ablation experiments and studies of non-linear effects in free clusters and atoms have been performed.

By changing the pulse compression scheme in the linear accelerator of TTF1 the pulse duration could be varied in the range between approximately 40 and 100 fsec. First computer simulations indicate that there is a possibility to vary the electron density distribution within a bunch in a way which should allow for a controlled variation of the duration of the photon pulse from the FEL. If this goal can be reached a further dimension to the unique properties of the X-ray free-electron lasers would be added.



Time-of-flight mass spectrum recorded after multiple ionization of xenon atoms at TTF1 VUV FEL. (see also the contribution of Wabnitz et al. to the 2002 HASYLAB Annual Report)

The first experiments at the TTF1 VUV FEL on free clusters by Thomas Möller and his collaborators have attracted large interest world wide including the optical laser community (see the *news and views* article by H.C. Kapteyn and T. Ditmire, *Nature **40** (2002) 467-468*). By modifying the experimental setup at TTF1 Wabnitz et al. also demonstrated ionization of rare gas atoms. Irradiating the atoms with 12.8 eV radiation ionisation states of up to Xe^{6+} were observed. From comparison with available theories it is concluded that the ionisation occurs in a step like process in stead of a simultaneous detachment of all ejected electrons from a neutral atom.

The TTF VUV FEL also attracts strong interest from the community interested in investigations of warm dense matter. As a consequence an International Conference on Warm Dense Matter with 45 presentations and a poster session followed by a FEL Experiments Planning Workshop took place at DESY on 3-7 June 2002.

On 25-27 September 2002 the first research proposals for the TTF2 VUV FEL were presented and

discussed by about 50 scientists, and afterwards reviewed by the extended HASYLAB Project Review Panel for the XUV spectral range. Following a call for proposals announced in spring 2002 HASYLAB received 19 applications. One of them, in which more than 70 scientists from 9 different countries are involved, comprises a dozen plasma physics related experiments including research on biological samples. 10 projects are proposing experiments using gas phase samples, ranging from fundamental studies related to the interaction of intense VUV pulses with atoms, molecules and clusters, to the spectroscopy of stored atomic and molecular ions, the investigation of mass-selected clusters, and time resolved studies using pump-probe techniques. 3 of these projects are largely technical developments for the VUV FEL facility concerning online measurements of the absolute energy of the FEL radiation pulses and their timing and temporal structure. Finally, several proposals are dealing with solid samples including studies on fast dynamics at surfaces, magnetism dynamics, nanospectroscopy, and inelastic scattering. The overall quality of the proposals was considered excellent. For more details see the contribution by J. Feldhaus and E. Plönjes in this Annual Report.

After signing a Memorandum of Understanding between the Stanford Linear Accelerator Center SLAC and the Deutsches Elektronen-Synchrotron DESY on establishing a collaborative research effort to enable the exploitation and expansion of the scientific capabilities of the Linac Coherent Light Source and the TESLA X-Ray Free-Electron Laser on 1 November 2002 in Washington DC: Left to right first row: Albrecht Wagner (DESY), Jonathan Dorfan (SLAC), and Jochen Schneider (DESY), left to right second row: Jerry Hastings, John Galayda and Keith Hodgson (SLAC)

As a result of the evaluation of 9 large scale facilities currently planned in Germany the German Science Council published a statement on 12 July 2002, which was transformed into a recommendation in the Council meeting on 13/14 November 2002. Both the TESLA Linear Collider and the TESLA-XFEL were supported under certain conditions, the status of the decision taking process is described in some detail in Albrecht Wagner's contribution to this Annual Report. In response to the requests by the German Science Council, DESY submitted a Supplement to the TESLA Technical Design Report describing the XFEL Laboratory with a dedicated linear accelerator in a separate tunnel. In addition a memorandum describing the future collaboration between DESY and BESSY in FEL R&D and the operation of the two facilities proposed for the Hamburg area and Berlin Adlershof, respectively, has been presented to the Science Council.

The scientific scopes of the Stanford Linear Accelerator Laboratory SLAC and the Deutsches Elektronen-Synchrotron DESY have much in common. Both laboratories pursue rigorously science programs in particle physics and synchrotron radiation research based on a strong accelerator science program. SLAC builds the Linear Coherent Light Source (LCLS), a SASE FEL which is

expected to provide 0.15 nm radiation in 2008, and offers with the Sub-Picosecond Photon Source (SPPS) the opportunity for first experiments with 80 fsec hard X-ray pulses from spontaneous undulatory radiation over 17 months from May next year up to the end of 2005. At DESY the TTF2 VUV FEL will provide FEL radiation down to wavelengths of 6 nm and should be available for users in 2004, and there is great hope for the realization of the TESLA XFEL Laboratory in the Hamburg area up to the year 2011. In order to combine forces SLAC and DESY concluded a Memorandum of Understanding on a collaborative research effort with the goal to insure the early success of the TESLA-XFEL and the LCLS scientific programs, and to carry out scientific research exploiting the unique capabilities of the TTF2 and SPPS sources.

Coming to current synchrotron radiation research at HASYLAB, DORIS III was operated from 14 February to 20 December 2002 with positrons at an energy of 4.5 GeV and initial currents of up to 150 mA in the 5 bunch mode of operation. At the best performance of DORIS lifetimes of about 25 hours at a stored current of 120 mA in 5 bunches were achieved. The nearly 5757 hours of scheduled dedicated user time were grouped in 8 blocks of 4 or 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. For experiments which need a special time structure, the storage ring was operated in reduced bunch mode for about 12 % of its running time. The operation efficiency of DORIS III was 92 %.

Due to the extended machine studies necessary at the HERA storage ring the operation of PETRA II as a synchrotron radiation source was limited to about 750 hours, mostly distributed equally over the entire year. Only in February/March a period of 4 weeks could be used for experiments in a block.

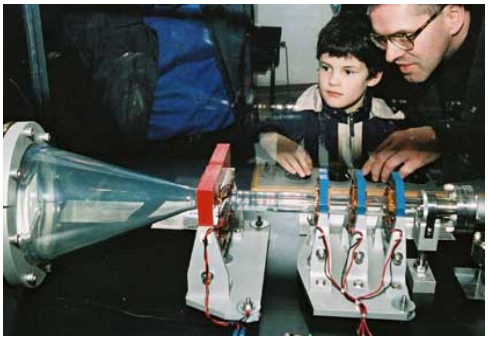
The Chemistry Department of the University of Hamburg, DESY, the GKSS Forschungszentrum Geesthacht, and the German Chemical Society (GDCh) organised a workshop on the “Application of Synchrotron Radiation in Chemistry – Status and Future”, which was attended by 40 participants from different fields of Chemistry. The scope of the workshop was to give an overview on current applications of synchrotron radiation and to discuss future applications in chemical research possible at 3rd generation facilities like PETRA III.

Within the series of research courses on new X-ray sciences, organised by Thomas Tschentscher, the second course on “X-ray Investigation of Fast & Ultrafast Processes” took place at HASYLAB. 50 participants from 10 European countries, mainly PhD students and young research fellows, attended this highly successful meeting.

The HASYLAB Annual Report 2002 is again published as a CD-ROM and an internet version, only a limited number of hard copies will be provided. It contains 723 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 2002 contains 261 institutes and about 1550 scientists. In the field of structural biology about 430 scientists from more than 117 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.
Different from previous HASYLAB Annual Reports we have included a sequence of 5 research highlights which were made available on the HASYLAB web site in the course of the year 2002.

22 000 visitors came to an exhibition showing the TESLA project with its Linear Collider for particle physics and the XFEL Laboratory, which took place at the Automobilforum Unter den Linden in the center of Berlin from 16 January to 17 February 2002. General informations on the science cases and the superconducting accelerator technology, as well as hands-on experiments

attracted the interest of a rather diverse audience including people from the business world – and that of many young people. About 70 school classes attended lectures and guided tours.



"TESLA – Licht der Zukunft"

DESY exhibition in the Automobil-forum of the Volkswagen AG Unter den Linden in the center of Berlin.

It is a great pleasure to congratulate Professor Ulrich Bonse, University of Dortmund, who received the Röntgenplakette of the city of Remscheid for his outstanding contributions to the development of X-ray sciences. Professor Gerhard Materlik, Synchrotron Radiation Facility DIAMOND at the Rutherford Laboratory and Oxford University, UK, who was a student of Professor U. Bonse, received the Röntgen-Prize of the University of Würzburg. It is a very special pleasure to congratulate Professor Materlik on behalf of DESY and HASYLAB to this award honouring his numerous important contributions to the progress of X-ray sciences and synchrotron radiation research. We are very pleased to congratulate Dr. Tobias Lau, Institute of Experimental Physics of the University of Hamburg, who received the Ernst-Eckhard-Koch Preis 2002 for his PhD on the origin of magnetism in small clusters deposited on a solid surface. With great pleasure we congratulate Dr. Thomas Möller, HASYLAB, who received the Bjørn H. Wiik Prize for his pioneering work on excitations of free clusters and atoms with intense VUV radiation from the TTF free-electron laser.

The high motivation of the HASYLAB staff and our external users, as well as the support of synchrotron radiation research by all colleagues at DESY, are at the origin of HASYLAB's success and very much appreciated. With the storage ring DORIS III, the upgrade plans for PETRA II, the VUV FEL at TTF2 and the strong hopes for the realisation of the TESLA-XFEL Laboratory in the Hamburg area, with the close collaboration with Hamburg University, with the EMBL Outstation, the MPG groups and the Thetis company for biological research on the DESY campus, and with the engagement of the GKSS Forschungszentrum Geesthacht in the field of materials science, research with photons at DESY has a unique perspective.

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