The Deutsches Elektronen-Synchrotron with laboratories in Hamburg and Zeuhthen has as its trademark the symbiosis of research in particle physics, based on the unique electron-proton collider HERA, with experiments at a dedicated synchrotron radiation source, based on the 4.5 GeV DORIS III ring.

The Deutsches Elektronen-Synchrotron

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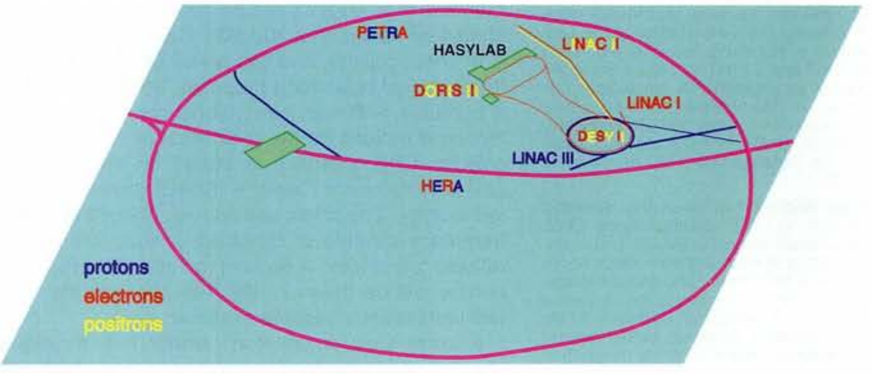
DESY and the 2nd Institute for Experimental Physics, University of Hamburg

DESY was founded in 1959 and research started in 1965 after completion of a 6 GeV electron synchrotron. The main areas of research at that time were elastic and inelastic electron-nucleon scattering, meson production in photon-nucleon collisions and tests of quantum electrodynamics (QED). In addition, research using the synchrotron radiation emitted by electrons traversing bending magnets was started soon after the accelerator was turned on.

The electron-positron collider DORIS became operational in 1974, starting a long and successful tradition in the construction and operation of colliders at DESY. DORIS was used, like its predecessor, as a source for synchrotron radiation, but the main highlights of the research during the first years of operation concerned particle physics. These included confirmation of the charm-quark and the tau-lepton, the first observation of excited states in the bound state of the charm-anti-charm system, and the observation of the fifth (or "bottom") quark. In 1982, the ARGUS detector at DORIS started to take data, operating with great success until 1992. One highlight among the many major results from ARGUS involving the decays of bottom- and charm-mesons was the first observation of the spontaneous particle-antiparticle transition in the system of neutral B-mesons.

PETRA, a new electron-positron storage ring, became operational in 1978. The major discovery at PETRA was the first, direct observation of the carrier of the strong force, the gluon, and the measurement of its spin. Other important results were the confirmation of quarks as the building blocks of nuclear matter and the observation of the interference between the electromagnetic and weak forces.



An aerial view of DESY and a plan of the main site. The approximately 2.3 km in circumference PETRA II ring acts as an injector for the HERA electron-proton collider ring. The DORIS III synchrotron radiation source and the adjacent HASYLAB are indicated.

A New Era with HERA and DORIS III

Research at PETRA came to an end in 1986 when the installation of the new electron-proton collider HERA began to be prepared. HERA offers a broad spectrum of research opportunities in particle physics, essentially because the weak and the electromagnetic forces are of comparable strength at HERA energies. The extension by nearly two orders of magnitude in the square of the momentum transfer in collisions implies that the proton can be viewed with a ten-fold improved resolution down to 10^{-18} m (equivalent to 10^{-3} of the radius of the proton). By extending these measurements down to values of 10^{-5} for the fraction x of the nucleon momentum carried by the struck parton, one enters into a new regime of very dense partonic systems. HERA is also well suited for searching for new particles with the quantum number of the electron, or with combined electron-quark quantum numbers.

In addition to the collider programme, HERA offers the intriguing possibility of performing high luminosity, high duty cycle, fixed-target experiments by installing internal targets in the electron and proton beams. Starting in 1995, the HERMES experiment will use longitudinally polarized electrons incident on polarized protons, deuterons and ^{3}He gas targets to investigate the spin structure of the nucleon. An experiment (HERA-B) designed to measure the charge-parity violation parameter in the $b\bar{b}$ system has been proposed. This experiment could yield its first data in 1998.

A Dedicated Synchrotron Radiaton Source

DESY entered a new era in synchrotron radiation-based research in June 1993 with the operation of DORIS III as a dedicated source. The accelerator ring, incorporating wigglers and undulators, is presently feeding 39 beam-lines equipped with a total of 83 instruments. Photons in the range between 1 and 300 000 eV are used for both fundamental and applied research in the fields of physics, biology, chemistry, materials science, and geoscience as well as in medicine. Meanwhile scientists from the Hamburg outstation of the European Molecular Biology Laboratory (EMBL) and from three Max-Planck-Gesellschaft groups are studying the structure of biomolecules at nine experimental stations. It was decided in 1993 to construct an undulator beam-line at the PETRA II storage ring which is now being used as a part of the HERA injection system.

MILESTONES

1957-59: Planning and foundation.
1960-64: Construction of the 6.0/7.5 GeV electron synchrotron.
1964: 55 MeV electron LINAC 1 starts operating.
The Deutsche Forschungsgemeinschaft builds up synchrotron research.
1967-73: Construction of the electron-positron double ring collider DORIS (2 x 3.5 GeV).
1969: 450 MeV positron LINAC II starts operating.
1972: Hamburg branch of the European Laboratory for Molecular Biology created at DESY.
1976-78: Construction of the electron-positron double ring collider PETRA (2 x 23 GeV).
1978-80: Construction at DESY of the Hamburg Synchrotron Radiation Laboratory (HASYLAB).
1979: Commissioning of the Positron Intensity Accumulator PIA.
1981-82: DORIS reconfigured as the single ring electron-positron collider DORIS II (2 x 5.6 GeV).
1984-88: Construction of the 7.5 GeV electron synchrotron DESY II and the 7.5 GeV proton synchrotron DESY III in the DESY tunnel.
Construction of the the 50 MeV proton injector LINAC III for HERA.
1984-90: Construction of the 30 GeV-820 GeV electron-hadron collider HERA.
1986: PETRA reconfigured as PETRA II — a 12 GeV electron/positron injector ring and a 40 GeV proton accelerator and injector for HERA.
1990-91: DORIS II is upgraded to DORIS III by the installion of 7 insertion devices.
1991: First collisions at HERA.
1993: DORIS III starts operation as a dedicated radiation source.
1995: PETRA II's x-ray undulator to start operation as a 12 GeV low-emittance radiation source.

The PETRA undulator, with photon energies above 20 keV, will provide an unique source of synchrotron radiation.

The Future

With HERA and the synchrotron radiation facilities, DESY has front-line research activities which will carry it well into the next decade. However, since it takes on the order of 10 to 15 years from initial planning to the realization of a new, large research facility, a decision on the direction of research at DESY must be taken in the second half of the 1990s. After extensive discussions, the DESY Scientific Council has recommended that DESY's future research programme should be based on a 300-500 GeV high luminosity e^+e^- linear collider, and has asked DESY to prepare the technical basis for a proposal. DESY is presently pursuing, within an international collaboration, two technical options for the realization of a large linear collider. One approach is based on the Stanford Linear Accelerator Center's (SLAC) proven S-band technology. The other uses superconducting radio-frequency cavities to construct a linac with much relaxed tolerances. A decision on which approach to pursue will be taken in 1997/98 after results from two test facilities become available.

A large electron-positron collider has a unique physics potential, complementary to that which will be provided by CERN's Large Hadron Collider (LHC) for proton-proton collisions. Moreover, by guiding the high quality, low-emittance electron beam from the linear accelerator through an undulator it appears possible to construct an x-ray laser for wavelengths down to 1 Å and even below. An e^+e^- collider facility would thus allow DESY to continue to pursue the symbiosis between particle physics and research with synchrotron radiation which has become its trademark.

DESY — Institute of High-Energy Physics, Zeuthen.

Jochen Schneider joined HASYLAB in 1989 and has been its Director since 1 January 1993. He studied at the University of Hamburg, receiving a diploma in 1968 and a Ph.D. in 1973 while working as an experimental solid-state physicist at the Institut Laue-Langevin, Grenoble. He joined the Hahn-Meitner Institute, Berlin, in 1976 and was awarded his *habilitation* in 1982 from the TU Berlin.

Paul Söding has been the Scientific Director at DESY-Zeuthen since 1992. He studied at the TU Munich and at the University of Hamburg from which he received a diploma in 1960 and a *habilitation* in 1966. He worked at the Lawrence Radiation Laboratory, Berkeley, USA, as a Research Associate before moving to DESY in 1969 to continue research in experimental particle physics. Appointed professor at the University of Hamburg in 1974, he served as DESY's Director of Research in 1982-91.

Gustav-Adolf Voss is the Director of DESY's Accelerator Division and Vice-Chairman of the Board of Directors of DESY. He studied at the TU Berlin, receiving a diploma in engineering in 1953 and a Ph.D. in 1955. After working for a short time at Giessen University and at DESY as a research fellow, he moved to Harvard University, Cambridge, USA, in 1959, becoming the Cambridge Electron Accelerator's Associate-Director in 1964. He returned to DESY in 1973 and was appointed professor at the University of Hamburg in 1974.

Albrecht Wagner has been the Director of Research at DESY and professor at the University of Hamburg since 1991. He studied at the TU Munich, and at the universities of Göttingen and Heidelberg, receiving a diploma from Heidelberg in 1964, a Ph.D. in 1971 and his *habilitation* in 1979. Apart from spending most of 1973 and 1974 as a Research Associate at the LBL, Berkeley, he worked as an experimental particle physicist at the University of Heidelberg from 1970, initially as a research assistant, becoming professor in 1984, and serving as the Director of the Physikalisches Institut in 1986-89.

Björn Wiik became the Chairman of DESY's Board of Directors and DESY's Director General on 1 March 1993. He studied in Bergen and at the TH Darmstadt, receiving a diploma in 1963 and a Ph.D. in 1965 for research in experimental nuclear physics. He worked as a Research Associate at Stanford University, USA, in 1965-68 and at the Stanford Linear Accelerator Center in 1968-72. He joined DESY in 1972 and became the HERA project leader in 1981, shortly before being appointed professor at the University of Hamburg.

INFORMATION

Further information about DESY can be obtained from Petra Harms, DESY, Postfach, D-22603 Hamburg. Tel.: +49 (40) 89 98 36 16; fax: +49 (40) 89 98 32 82.

DESY AT A GLANCE

DESY is funded by the German Federal Ministry of Research and Technology and by the City of Hamburg (DESY-Hamburg) and the *Land* of Brandenburg (DESY-Zeuthen) in the ratio of 9 to 1. The laboratories have a permanent staff of 1269 and the total 1994 budget is 279 MDM, of which 252 MDM are earmarked for DESY-Hamburg.

Although DESY was originally founded to provide research opportunities for German universities, it has developed over the years into an international research centre with nearly 2000 users from 25 different countries, split about evenly between particle physicists and synchrotron radiation users. The international character of DESY is particularly visible in the HERA project. HERA was constructed within the framework of an international collaboration where institutions in Canada, the former Soviet Union, France, Israel, Italy, The Netherlands, Poland, the People's Republic of China, United Kingdom, and the United States provided either components built at home or delegated skilled manpower to work on the project. Utilization of HERA is also truly international, as roughly 60% of the 900 physicists collaborating in its two, large, multipurpose, collider detectors H1 and ZEUS are from non-German institutions.

DESY has very close connections with groups from many universities and thereby contributes in a major way to the training of students in particle physics and detector development, and in research with synchrotron radiation.

DESY - Institute of High-Energy Physics, Zeuthen

Since January 1992, DESY has operated the former Institute for High-Energy Physics of the Academy of Sciences of the German Democratic Republic. Sited at Zeuthen near Berlin, it became a branch institute under the title DESY — Institute of High-Energy Physics, Zeuthen. Founded in 1950 as the Institute for Nuclear Research, Zeuthen became oriented purely towards high-energy physics (HEP) in 1962, and it was here that the former German Democratic Republic (GDR) concentrated most of its research work in the field.

Lacking their own HEP facilities, east German experimentalists had to turn to either the former Soviet Union (Joint Institute for Nuclear Physics, Dubna, and the Institute for High-Energy Physics, Protvino) or to CERN, Geneva, although they were allowed for a few years in the 1960s to participate in the first experiments at DESY. Bubble chamber experiments, later complemented by work with streamer chambers, neutrino detectors and deep-inelastic muon scattering, were for several years the principal activities.

In the 1980s, participation in CERN experiments intensified and work at DESY eventually even became possible again. The Institute joined the L3 collaboration at the electron-positron collider LEP at CERN and participated in building the L3 detector by constructing in Zeuthen parts of the central tracking system. It also participated in the construction of the H1 detector at HERA, and contributed two of the wire chambers of the detector's tracking system. Preparatory work for constructing an underwater neutrino telescope in Lake Baikal was started in the 1980s in collaboration with several Russian groups (see page 98).

After the unification of Germany, the government had the federal Science Council evaluate all the Academy institutes of the former GDR and make recommendations on their future. The Council took little time to propose that the Institute for High-Energy Physics should be essentially retained and integrated into DESY. Thus, after a change in DESY's statutes, the *Land* of Brandenburg joined Hamburg and the Federal Republic as the third trustee of DESY. In supporting DESY-Zeuthen, it is committed to covering 10% of DESY's budget. The number of staff positions in Zeuthen had to be reduced from the original 220 to 136, with about 40% of the positions for scientists or academically trained engineers. However, the Institute has successfully attracted many new postdocs and students during the last years.

Those projects that were already well underway before the merger with DESY-Hamburg remain today an important component of the research programme at DESY-Zeuthen. Work in the L3 collaboration at LEP is actively pursued, with analysis of Z^0-resonance data and participation in upgrading the detector in view of the future experiments at the upgraded LEP-200 machine. The H1 involvement at HERA focusses on both data analysis and the upgrade of the existing detector. After unrestricted travel to western Germany had become possible in 1990, many physicists from Zeuthen joined other experiments at DESY in Hamburg — which is only about 300 km from Berlin — thus strenghtening the involvement with DESY even further.