The Deutsches Elektronen-Synchrotron with laboratories in Hamburg and Zeuthen 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.

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 quantum numbers of nuclear matter and the observation of the interference between the electromagnetic and weak forces.

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, especially 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 transferred 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^{-6} 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 quantum numbers of quark and antiquark.

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 longitudinally polarized protons, deuterons and 3He gas targets to investigate the spin structure of the nucleon. An experiment (HERA-B) designed to measure the charge-parity violation parameter in the b5 system has been proposed. This experiment could yield its first data in 1998.

A Dedicated Synchrotron Radiation 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 0.5 and 20000 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.
1967-73: Construction of the electron-positron double ring collider DORIS (2 x 3.5 GeV).
1965: 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 of the 50 MeV proton injector LINAC III for HERA.
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.
1990-91: DORIS II is upgraded to DORIS III by the installation 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, 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 option uses 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 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 1,269 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 2,000 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 with 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 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. Situated 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 research 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 downstream 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 status in 1990, 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 analyses of Z* resonance data and participation in upgrading the detector in view of the future experiments at the upgraded LEP-200 machine. The H1 experiment at HERA focuses 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 strengthening the involvement with DESY even further.

INFORMATION

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